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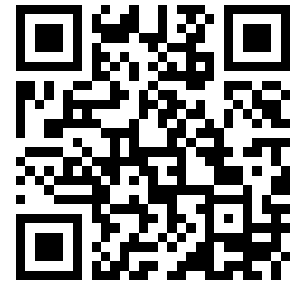

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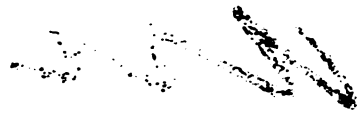

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THE ELECTRICIAN:

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NOTES.

The President of the Board of Trade having cordially approved and Lord Kelvin having acquiesced; after the word "unit" in the Provisional Orders of this year, the words "hereinafter called a kelvin" will be introduced. The correspondence upon this subject will shortly be published.

The question of the suitability of the name is beyond criticism, and no exception need be taken to the use of a name of one who is still living. The question of the need for any name is another matter, and one on which we have on a former occasion expressed some doubts. Many of our readers will agree with us that in discussing the supply of electrical energy the simple word "unit" is sufficient, and no more ambiguity arises than when "a thousand" is alluded to in talking of gas supply. It must be admitted that the word "unit" is sometimes employed to denote an integral element of the generating plant of a station, but that is the fault of those who gave it this name. The word "unit" is also employed to express the output of a dynamo, though the word "kilowatt" is slowly gaining ground. There is no confusion here. A 100-kilowatt dynamo generates 100 units in an hour. We have never felt the need of any other word than "unit," but then we can generally manage, without much difficulty, to avoid using the expressions "electromotive force" or "electricity." Those who really feel the want of a better word than "unit" ought to be satisfied; and time will show how many there are who prefer the "kelvin." The schoolboys of the future will learn to say:—

1,000,000 ergs	make	1 meg-erg.
10 meg-ergs	,,	1 joule.
3,600 joules	,,	1 watt-hour.
1,000 watt-hours	,,	1 kelvin.

We have given the new word a fair trial in some of the following Notes.

The conversazione of the Royal Society on Wednesday was in no way less interesting than usual. Dr. J. T. Bottomley dealt with Teslaic discharges in vacuum tubes without electrodes, using a quart bichromate battery and a small coil. These tubes were made several years ago. Mr. Wimshurst showed Leyden jars with coatings of insulated wire; Dr. Oliver Lodge, besides some beautiful optical effects, illustrated a possible interpretation of the rod and cone structure of the retina by the electrical oscillations in cylinders vibrating across a diameter. Captain Holden exhibited a number of electrical instruments, and Prof. Crookes provided brilliant high frequency experiments. Messrs. Pyke and Harris showed an inductor dynamo and a large number of vacuum tubes worked at 100,000 volts from a transformer provided with oil insulation, the oil being kept in continuous circulation through a dehydrator of sodium. A current of three amperes at 100 volts from the main of the London Electric Supply Company was used. An arrangement of condensers, formed of pieces of tinfoil on a large sheet of glass, enabled vacuum tubes of different sizes to be run in parallel.

The attraction of the evening was the exhibition of the photographs by Prof. Vernon Boys, of flying rifle and pistol bullets. The electrical arrangements were of great interest, and the results were marvellous. It might be thought that this is a mere feat of photography, and that it differs only in degree from "kodaking" an express train. But in the hands of Prof. Boys the flying bullet teaches as many physical truths as a soap bubble, and is the more interesting since the hyperbolic air waves in front, the trail and vortices in the wake, their inclinations, mutual reactions, and other subsidiary phenomena have never before been visible or even thought of. These photographs have been shown at a lecture at South Kensington and again this week at the Royal Victoria Hall. We strongly recommend our readers to endeavour to be present at the next public demonstration, of which we hope due notice will be given.

There is every reason to expect that Mr. Holroyd Smith's electric traction experiment at Bradford will result in the adoption of the system by the energetic Corporation of that town. There is no question here of competition with horses. Horse traction is out of the question on most of the Bradford lines, which are worked with noisy, dirty, and expensive steam locomotives, drawing "two-deckers" seating 68 passengers. The Corporation have allowed Mr. Holroyd Smith to make a demonstration on a length of 660 yards of line in the middle of the town, and it must be admitted that a more difficult piece of line would be hard to find. The first 170 yards has a slight incline, averaging 1 in 150. Then 293 yards, with a rise of 60 feet, having a gradient of 1 in 13¼, and on this hill the street curves sharply round to the right with a radius of about 35 feet. After this is a length of 293 yards, with a gradient of about 1 in 90. Up this hill a car weighing 6½

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tons can carry 43 passengers at about 8 miles an hour, the mechanical work alone, Mr. HOLROYD SMITH informs us, being about 35 H.P. During an experimental run three times up and down the line, taking a fully loaded car up the hill on each occasion, besides a little manœuvring on the level, $1\frac{1}{3}$ kelvins were used.

A TROLLEY line is at present used at Bradford, and it rests entirely with the Corporation whether, in the event of the adoption of electric traction, this shall be made permanent, or whether a slotted conduit shall be used. The current is provided at present from the two smaller dynamos of the electric supply station, and thus the local authorities can satisfy themselves with ease as to that part of the cost. It is an excellent feature of this experiment that the Corporation who own the lines should be in a position to settle the system of conductors, and should be able to provide the current themselves, thus reducing the matter to a simple question of mechanical engineering.

THE motors and driving gear, which have been built by Messrs. EASTON and ANDERSON, present several interesting features, which we hope to describe on a future occasion. Having such a stiff piece of line to encounter, more driving power than is actually needed has been provided. There are two "dual armature" motors. That is to say, there are four armatures and two pairs of field-magnets. Each armature drives a separate wheel by means of worm gearing, the details of which are the outcome of a considerable amount of experiment. Ball thrust-bearings are used. These armatures can be coupled all in series, or in two parallel sets in series, or all in parallel; resistances are also provided. With the second arrangement a car designed to accommodate 36 passengers but loaded with 47, climbed the hill and curve at about five miles an hour.

A VERY ingenious use has been made of these four armatures on the Bradford car for applying a powerful brake going down hill. They are disconnected from the supply of current, and are all joined in series; the resistance being low, they generate a considerable current which allows the car to move only at a creeping pace. There is a tendency to stop dead and then to run on a little, and as soon as the motors begin to generate, to stop again. Mechanical brakes and reversing gear are of course provided as well. The work has hitherto been completely successful. A rumour was current in the district some weeks ago that two armatures had burned out. This was without foundation, and arose from the failure of the end-insulation of the commutators. The current does not exceed 75 amperes, and is generally limited to 50, there being no difficulty at all in this respect.

JUST as we go to press we learn that General HUTCHINSON has inspected and has officially passed the Bradford electrical traction system, which will now run regularly for public service.

WE learn from the *Scientific American* that Representative STOUT, of Michigan, has been moved by the recent Berliner transmitter scandal to bring forward a resolution requesting the Committee on Patents to ascertain "whether any modification of the patent law is necessary to protect the public against undue monopoly." Our American contemporary points out in characteristic phraseology that if the Supreme Court upholds the Berliner patent, "the public will be cornered again, and subjected to prolonged corporate squeezing," and sensibly suggests the abolition of the present system of official examination into the novelty of inventions, with its tedious delay in issuing patents and its mysterious "interference" proceedings.

PATENT literature, like all other printed matter, has enormously increased of late years; and investigations into the novelty of inventions, if they are to afford any guarantee to the patentees who, in the end, pay the piper for them, must, as years go on, become more and more costly and tedious. The principle of *caveat emptor* seems peculiarly applicable to those who take out patents; these should be nothing more than outward visible signs that the holders of them consider themselves entitled to certain privileges, and if anyone thinks otherwise let the law decide. If the Governments which favour the system of examination regarded infringers as social pests, and took it upon themselves to defend the validity of the patents which they issue, it would be another matter altogether.

THE Americans are notoriously great revellers in statistics, and if their figures were more frequently of the kind presented at the recent annual meeting of the Thomson-Houston Company at Middleton (Conn.) we should have good cause to envy them this amusement. The share capital of the Thomson-Houston Company is $10,000,000, say two millions sterling. Business during the past year, we are told, has not been quite so active as could be wished; nevertheless, it has been found possible to pay 7 per cent. on the preferred stock, 16 per cent. on the ordinary shares, and to add over £300,000 to the "surplus account," which now stands at about £1,500,000. At the end of 1882, the business turnover at the Boston office was only some £85,000; to-day it amounts to considerably more than £2,000,000. The activity in local company enterprise has slackened, nevertheless 118 concerns were launched in 1891, making a total of 873 companies employing 100,000 arcs and 800,000 incandescents, all manufactured by the parent firm. As to railway work, no less than 204 are at work or under contract, having an aggregate mileage of 2,500 miles. When will a leading English electrical manufacturing firm be able to pay a *bonâ fide* 16 per cent. dividend and put by a sum equal to one-seventh of its capital? We reel at the thought of the dinners which will have to be given in order to properly celebrate the event.

SUPPLY stations are built for those that pay for them, and Papers describing them are written for the audience to whom they are addressed. The unaccountable reticence of Mr. SHOOLBRED at the Society of Arts on Wednesday last on the subject of the lamp connections at Bradford was fortunately defeated by the frank information given by Mr. BAYNES. The

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number of lamps connected which is the chief item of commercial importance and interest to engineers, is at present equivalent to 19,000 eight-candle lamps. The earning capacity per lamp, which Mr. SHOOLBRED attempted either to conceal or to ignore, is 20 kelvins per annum; or 9s. 7d. per lamp fixed, at the date of the last balance-sheet. The excuse was put forward, that a local authority has nothing to do with lamps, that a statement of the number of lamps is "misleading" and "delusive." If not interesting to Mr. SHOOLBRED, the capital per lamp fixed, and the revenue per lamp, were items which some of his audience thought to be worth eliciting. Mr. FRANK BAILEY pointed out that the average proportion of lamps burning at the heaviest load was about 50 per cent. of the lamps connected, showing a much better ratio than in London, where 33 per cent. is the rule. He added that a careful record of the number of lamp connections gave a valuable warning against the overloading of the plant during fogs.

As a catalogue of the plant put down by Messrs. SIEMENS and others and an assurance that it was running well, the Paper of Mr. SHOOLBRED fulfilled its purpose; but had it not been for the discussion, which we hope will appear in the *Journal* of the Society of Arts, several facts of real interest would not have been forthcoming. Mr. CROMPTON pointed out that from a rough calculation, the coal appeared to come to about ½d. per kelvin (he did not use this expression, but we want to see how it looks), while the cost per ton was about one-third of the London price, and asked whether any figures could be given showing the performance of the boilers. Mr. BAYNES was able to give this information. Each pound of fuel evaporated 6·84lbs. of water, and this, allowing for the working pressure of 140lbs. per sq. in. gave 7·59lbs. of water evaporated from and at 212°, per pound of fuel.

A VALUABLE feature of the balance sheets of undertakings such as the electric supply of Bradford is that being in the hands of the Corporation they are free from trade bias. Their testimony, as Mr. CROMPTON put it, is untainted; but Mr. GARCKE pointed out that, on the other hand, local authorities are tempted to present a favourable account of their doings, and that they have great facilities for distributing their expenditure over the accounts of the different departments. He observed that no figures were given for rent of offices, clerks, insurance, and other items. Mr. ALBRIGHT and others inquired whether the 2½d. per kelvin included depreciation of mains, &c. Mr. SHOOLBRED, in reply, pointed out that neither interest nor sinking fund were included, and that depreciation would form part of the latter. One other omission will, we hope, be remedied in the next report of this station, viz., the ratio between the units generated and the units sold. With resistances inserted in the feeders, and batteries even of the CROMPTON-HOWELL make, this ought not to be neglected.

MR. ALEX. SIEMENS made one or two remarks about the advantage of placing gas, water, and electric supply in the hands of a common authority, and thought that storage batteries were useful only for toy stations where a few hundred amperes would suffice for the light load. He followed a rather commonplace remark about the flattening out of the load curve when use of motors is extended, by an oracular hint at some new thing, whether invention or application of electrical energy we know not; but "something that will startle battery people!"

APROPOS of mysteries, the copper market is said to be staggering under the shock occasioned by the discovery of a new conducting material. If this is nothing more than aluminium at 2d. a pound we have heard of that before; but speaking of new metals, we hope shortly to present to our readers an account of a new, and probably very important, process for making bar copper direct from the ore.

Electrical Bills in Parliament.—The London County Council (Subway) Bill was read a third time in the House of Commons last week.

Electricity in Cotton Manufacture.—We have received from the Electrical Department of the Agricultural and Mechanical College of Auburn (Ala), a sample of the first cotton "ginned" by electricity.

Derby.—At a meeting of the Town Council, on Wednesday, a recommendation that the Corporation should undertake the lighting of the central part of the town by electricity and devote £30,000 to the work was unanimously adopted.

Obituary.—The death is announced of the Vicomte de Vougy, who was at the head of the French Telegraph Service from 1854 to 1870, and who was most energetic in bringing about the first International Telegraph Conference of 1865.

Copper.—Copper is 12s. 6d. a ton lower in price than it was a month ago. The visible supply of the metal is 53,828 tons, compared with 54,311 tons on March 31st. During the month the deliveries in England and France were 9,441 tons, and the supplies 8,958 tons.

Preston.—About half-past nine o'clock on Saturday morning last an explosion took place in the National Electric Supply Company's mains in Lancaster-road. At the time stated, a workman was going down with a lighted candle to examine a main. It is supposed gas had got into the mains.

Institution of Engineers and Shipbuilders in Scotland.—At the annual general meeting of this Institution held last week, premiums of books were awarded to Mr. Henry A. Mavor for his Paper on "The Development of Electric Distribution;" and to Prof. Andrew Jamieson for his Paper on "The Electric Lighting of Public Buildings."

Vertical Beams.—Lieut. Froud, secretary of the Shipmasters' Society, has written to the papers stating that to help in further testing the "vertical beam" idea, Mr. Ronald Scott has volunteered to project a vertical beam of light from the Crystal Palace at 9 to 9:15 every week-day evening during the present month. The committee of the society would be glad to receive the notes of any observer.

Telephone Trunk Wire Extensions.—The Exeter Telephone Exchange was last week connected with Newton, Torquay, and Plymouth. The trunk tolls from Exeter (in each case for three minutes' conversation are as follows:—Newton Abbot (22 miles), 6d.; Torquay (28½), 6d.; Paignton (32), 6d.; Brixham (40½), 9d.; Dartmouth (44), 9d.; Totnes (38½), 9d.; Buckfastleigh (45), 9d.; Ashburton (48), 9d.; Plympton (58), 9d.; Plymouth (62½), 9d.; Rame Head (98½), 9d.

Accident with an Electrical Coal Cutter.—A fatal accident took place at Glass Houghton Colliery, Castleford, on Wednesday. Mr. W. P. Bannister, an electrical engineer, about 22 years of age, was experimenting with a coal-cutting machine, when by some mishap he got entangled in the machine, and

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his left leg was cut completely off by the coal cutter, the other leg being severely crushed. He was removed to Leeds Infirmary, where he expired shortly afterwards.

International Horticultural Exhibition.—The electric lighting of this Exhibition is carried out with 210 10-ampere arcs, run 30 in series, eleven 40-ampere projectors being used in the arena. The dynamo plant consists of eight 30-lighters, two compound 17-unit machines for the projectors, and two Mordey alternators capable of supplying 1,000 glow lamps. The engines and boilers are by Davey, Paxman and Co. The whole of the above was installed by Mr. A. H. Wood within five weeks.

Bristol.—The Electrical Committee of the Town Council held a meeting last week for the purpose of selecting tenders for dynamos and boilers for the Bristol central station. There were about a dozen tenders for dynamos, and eight to ten for boilers. The lowest tender for dynamos was that of Messrs. Siemens Brothers and Co., at £14,011, and the lowest for boilers that of Messrs. Tinker Brothers, of Hull, at £7,450, and these were accepted by the committee. For dynamos the figures ranged from £14,011 to about £20,000, and for boilers from £7,450 to about £10,000.

Telephone Wires and Electric Light Mains in Glasgow.—On behalf of the New Telephone Company, application has just been made to the Glasgow Corporation Electric Lighting Committee to enter into an arrangement whereby the Company would be enabled to lay their telephone wires alongside of and at the same time as the electric light cables that are shortly to be put down within the central area of the City. The Committee have considered the application, and have resolved to recommend that it is not desirable or expedient that the Corporation should enter into any such arrangement.

The Signal Light of the House of Commons.—In answer to a question with reference to this matter, Mr. Plunket stated in the House of Commons, on Monday, that the cost of the signal light per Session was £60. The initial cost of substituting an electric light, as suggested, would not be less than £750, and its annual cost £150. He believed, however, that it would be possible to rearrange the existing light so that with the assistance of lenses it could be made visible all round, at an initial expense of, approximately, £400 or £500. He could not undertake to carry out any change this Session, but would take care that it was considered in connection with next year's estimates.

Cable and Land Line Interruptions and Repairs:

	Date of interruption. 1891.		Date of repair. 1892.
Brest-St. Pierre Cable (Anglo-American)	Nov. 19	.....	April 22
	1892.		
Perim-Assab Cable	Jan. 5	.....	March 26
Saigon-Bangkok Line	March 29	.....	*
Bagdad-Bassorah Line	April 13	.....	April 14
" "	" 24	.....	" 26
Anglo-French communications	" 16	.....	" 17
Siberian Line (Blagowestschensk)	" 20	.....	" 20
Bolama-Bissao Cable	" 23	.....	*

* Not yet repaired.

The Electric Lighting of the Chicago Exhibition.—"The course of events in regard to the award of contracts for lighting the World's Fair, as well as for the power plant," says the *Electrical Engineer* of New York, "has been somewhat extraordinary, and on the whole the situation is one to be regretted. . . . We note some very vigorous comments in the Chicago newspapers on the figures, and must admit that a most unfortunate showing has been made. Such an enormous reduction can only be interpreted by the public to mean either that a tremendous profit was sought for in the first instance, or else that the work has now been taken at a terrible loss to keep out competitors. Both aspects of the case give a bad impression."

Royal Institution.—At the annual meeting of this Institution, held on Monday, Sir James Crichton-Browne in the chair, the annual report of the Committee of Visitors for the year 1891 was read and adopted. The real and funded property now amounts to above £83,000, entirely derived from the contributions and donations of the members. Fifty new members were elected in 1891. The books and pamphlets presented amounted to about 248 volumes, making, with 517 volumes (including periodicals bound) purchased by the managers, a total of 765 volumes added to the library in the year. The following were unanimously elected as officers for the ensuing year:—President, the Duke of Northumberland; treasurer, Sir James Crichton-Browne; secretary, Sir Frederick Bramwell.

English Engineering Exhibits and the Chicago Exhibition.—The following extracts from a letter by Mr. R. H. Tweddell to last week's *Engineering* are decidedly to the point:—

"As I before said, it is all a matter of business. The sentimental features of Exhibitions began and ended with that of 1851. The promoters of such shows and their electrical tea gardens are after all only advertising agents, and then not half so efficient or customer-reaching in their effect as the columns devoted to that purpose in your own and similar leading journals. . . . . The question of exhibiting, so far as mechanical engineers are concerned, seems to be entirely a monetary one. Will any return result to compensate for the outlay? I think not—not even for specialities—and for ordinary engineering work the duties are prohibitive so far as our sending work to the States is concerned. I do not think we need fear French or German competition; and so far as the Columbian Exhibition is concerned, interesting and wonderful as it promises to be in many respects, I do not see how it is to affect the engineering trades. The question of the command of South American and other markets will be decidedly the relative cost of labour, transport and materials in the States and in Great Britain."

Incandescent Lighting of the Chicago Exhibition.—After nearly two weeks' deliberation, says the *Western Electrician* of April 23rd, the World's Columbian Exposition, acting on the recommendation of Directors R. C. Clowry and Charles H. Schwab and Electrical Engineer Sargent, of the construction department, has decided to award the contract for furnishing the 93,044 incandescent lights needed for the World's Fair to the Edison General Electric Company at the rate of $5.95 per lamp for the period of time named in the specifications. The price named includes dynamos, station apparatus, mains, inside wiring, sockets, lamps, and renewals. The Edison Company's original price for this work was $18.49 per lamp. At the rate agreed upon the contract will amount to $553,611.80. The arc lighting will cost about $120,000. The offer of the Western Electric Company to furnish generating capacity for 2,500 lamps for $1 will be accepted.

St. Pancras Vestry Electric Light Station Dynamos.—There are eleven Kapp-Willans combinations at this station. The engines are of the latest triple expansion type, and the dynamos are Messrs. Johnson and Phillips' central station multipolar machines, manufactured under Mr. Kapp's patent. Of these eleven dynamos six are wound for an output of 680 amperes at a maximum of 130 volts; three are wound for an output of 680 amperes at a maximum of 145 volts. The compactness of the combination is shown by the fact that each 90-unit steam dynamo only requires an area of 10ft. 6in. by 5ft. 6in. of floor space. At the official trial at Thames Ditton the combination showed a consumption of steam equal to 18·65lb per E.H.P. per hour. The remaining two dynamos are wound for an output of 90 amperes, at a maximum of 580 volts, for supplying current to the Brockie-Pell street lamps, or for charging in series four sets of 60 secondary batteries at the central station. These dynamos are separately excited from the low-pressure circuit. At the official trial of this combination the steam consumption was equal to 19·61b. per E.H.P. per hour. At present there are only 28 arc lamps in use, which are worked in four parallels of seven in series, but it is likely that these will shortly be increased to 90, and would be worked in nine parallels of 10 in series, thus taking up the load of one dynamo, the other being held in reserve. The lamps already installed are of the double carbon 32-hour type, being specially designed for street work. Each lamp is erected on an ornamental cast-iron post at a height of 25ft. from ground level to centre of the arc; the distances between posts vary from 160ft. to 245ft. In a chamber at the base of each post a double-pole switch, mounted on an oil insulator, is fitted, which switch allows of the lamps being cut out of circuit. Alternate lamps are put on different circuits, so that at any specified time half of the lamps can be switched out at the central station, leaving the intermediate lamps still in circuit As is well known, the whole of the works have been designed and carried out by Prof. Henry Robinson.

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NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 659.*)

9. Underrunning.—By referring to the cable chart and splice list, it is often possible to avoid the making of a new splice close to an old one, and so adding unnecessarily to the joints in the cable. For instance, while picking up towards a fault,

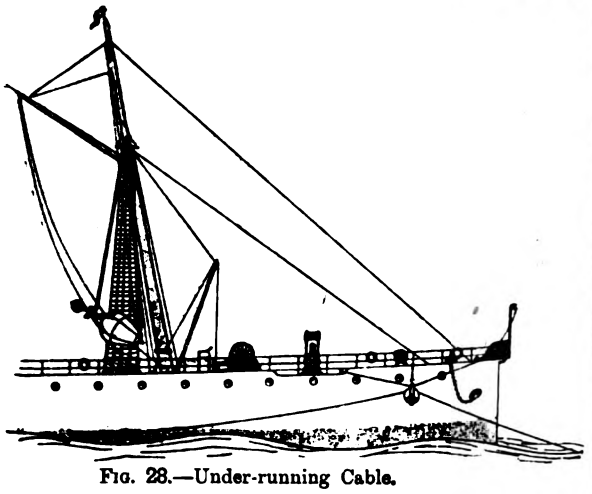

FIG. 28.—Under-running Cable.

say that the tests make it about three miles further on. This estimate may or may not be correct, and the fault may still be seaward when the cable is cut at this distance. At any rate, if the chart indicates a previous splice existing one mile beyond

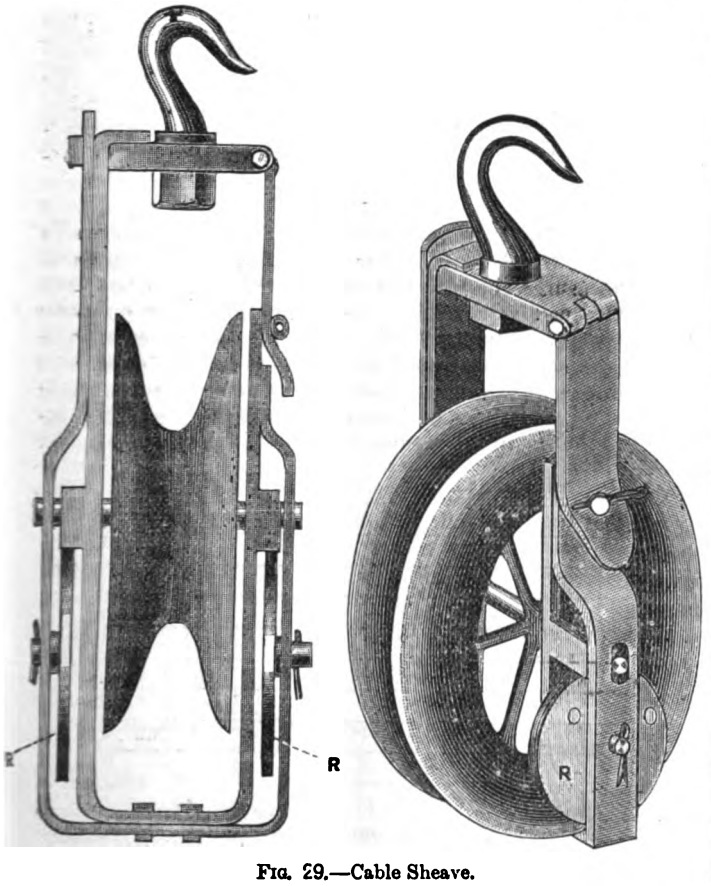

FIG. 29.—Cable Sheave.

the estimated distance, it will be better to pick up the four miles and cut at the splice, so saving an extra joint in the cable.

Again, when repairing in shallow water, it is sometimes possible to avoid a fresh splice in a heavy shore end by underrunning up to a previous splice. Say the fault to be removed is within ten miles of shore, and that the tests locate it within two or three miles of a splice about eight miles out.

In cases such as this it is advisable to make the first cut at the splice, and the ship will accordingly grapple for the cable as near to this splice as possible. When hove up it is seen by the type of cable towards which direction the splice lies, and, without cutting, the cable is underrun up to the splice. This is effected by lifting the bight off the grapnel and passing it over a large sheave suspended at the bows, and guyed in position by chains as shown (Fig. 28). The sheave employed is two or three feet in diameter, and is in principle similar to a snatch-block. In Fig. 29 one of these portable cable sheaves is shown, in which friction rollers, R R, are applied, making the running of the sheave very true and easy. On steaming slowly ahead the cable is drawn up over the loose sheave of the block, over which it rides back into the sea. This is continued till the splice appears, when the bight is heaved in and the cable cut and tested. The ship then buoys the end which tests all right, and picks up on the other end to the fault in the usual way.

Up to about 15 miles from shore, and in shallow water up to about 40 fathoms, it is often practicable to repair a cable without calling in the services of the repairing steamer. Either a good size steam tug, or a barge taken in tow by a tug, may be speedily rigged with all the necessary gear. The barge in tow is the more serviceable as regards the room on board for coiling and for fixing a temporary paying-out brake. This kind of repairing work near shore with lighters and steam tugs we shall refer to again, but as regards under-running, the repair of a total break near shore is very well effected in this manner. The sheave for underrunning is rigged up on the fore part of the barge exactly as described above, and the cable is first dredged for close in shore. The bight is then put in the sheave, and the tug steams ahead. When a steam tug alone is used, the sheave is rigged on the weather side so that the vessel can swing clear of the cable to leeward. By doing so, she can be steered better and her head kept up to the cable. The strain on the seaward end of the cable becomes visibly lessened as the break is approached, and the tug is eased down while the end is got up and stoppered on to the mooring-chain for buoying. The other end is then dredged for, cut and spliced on to a length of spare cable on the barge, and payed out to the buoyed end. The final splice is then made and the cable dropped overboard. Mr. A. C. F. Webb, the first to introduce under-running, which he practiced in repairing the Hague cables from the Dutch coast in 1853, relates in his interesting Paper "On the Practical Operations Connected with Paying Out and Repairing Submarine Telegraph Cables," read before the Institution of Civil Engineers, in February, 1858, how he effected the repair of a break 10 miles out from this coast during the severe winter of 1854, in a Dutch fishing smack. The difficulties he surmounted in this, one of the earliest instances of under-running, were peculiarly great. So much ice abounded that it was deemed too risky to employ a steam tug for the purpose, and the fishing smack being dependent upon the wind, became useless in the finest and most favourable weather. At such times the cable was pulled in over the sheave by manual labour, and the smack in this way propelled. The cable was taken over a sheave fixed at the head of the vessel close to the bowsprit, and then passed over a block hanging on the weather side of the vessel forward of the rigging, so that the cable passed over a portion of the fore deck. After successfully under-running the cable up to the break and buoying the end, all work had to be suspended for ten days, the ice meanwhile carrying away the buoys; but the whole of the cable was under-run a second time and buoyed again, and this time the other end was dredged up and a piece spliced in successfully. The repair, which involved great anxiety and danger, occupied altogether three months, during which Mr. Webb and his assistants were exposed for whole nights to the bitterest weather.

10. Capacity of Tanks.—While cable is being coiled on board during the operation of picking up, we may for a moment consider the approximate lengths of cable that can be stored in the tanks. It is not to be imagined that the whole of the tanks on board are ever completely filled with

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cable. Ships with four tanks could, as far as the amount of cable carried at one time is concerned, generally dispense with two; but the stowage of cable has to be regulated with regard to the trimming of the ship, and hence the total dead weight of cable is divided fairly evenly between the various tanks. While cable is being coiled on board ship from the manufactory or from reserve tanks on shore, the draught of water at the bows and stern is carefully watched, with the view of keeping the vessel in good trim. If too much is put into the aft tanks, and she is down by the stern, it will not be an easy matter to keep the vessel on her course under a beam wind or tide, the fore part of the ship being light. The tanks are usually not more than one-half or two-thirds full, the capacity of some ships being such that their tanks, if quite full, would hold enough armoured cable to sink them.

(To be continued.)

THE SUPPLY OF ELECTRICITY AT BRADFORD.

The Corporation of Bradford has been the first to municipalize the supply of electricity, and the undertaking has been highly successful. The local electric light work in this district was not remarkable either for quality or quantity, and it is chiefly to the exertions of Alderman Priestman that the town of Bradford owes the advantage of an electric supply.

The station presents no remarkable features or any novelties of particular interest to electric light engineers. It was started in 1889, and may be said to be representative of Messrs. Siemens' work, as the whole of the electrical plant is of their design and manufacture, and was erected by them. The Corporation is fortunate in having plenty of space, but the plant is compactly arranged, and can be considerably extended. There are six Willans sets and one Marshall. The first pair of Willans engines are coupled to Siemens dynamos in the usual way, and give a nominal output of 600 amperes at 150 volts at 285 revolutions per minute. The Marshall engine is inverted double acting, with cast-iron standard and wrought-iron pillars; it runs at 185 revolutions, and drives a dynamo giving the same output as those already mentioned. A very heavy and rather clumsy governor disfigures the appearance of this engine, which would be better suited for lower speed. Two triple Willans engines drive larger dynamos, giving 1,200 amperes at 300 and 350 revolutions, the volts being 150. Finally two small Willans-Siemens combinations give 300 amperes at 425 revolutions. These smaller sets are useful for day work and charging the batteries, but the diversity of sizes prevents the use of interchangeable armatures and other spare parts; while it does not appear to conduce in any material degree to better economy. The boilers, as might be expected in this part of the country, are of the Lancashire type, 7ft. diameter, 28ft. long, and supplying to the engines at 120lbs. pressure. The steam piping is not duplicated, and reliance is placed on branch and other stop valves for maintaining steam supply in case of a breakdown. A Babcock-Wilcox boiler is being set to assist in meeting sudden demands for current. A battery of Crompton-Howell cells of 1,000 ampere hours capacity and a normal discharge of 200 amperes was added to the station in 1891. A single discharge-switch is used in connection with it. The switch gear and cutouts, &c., are all of Siemens' design, some of the voltmeters are of the Schuckert type, and are used as indicators rather than voltmeters. A Thomson voltmeter is used as a standard for actually reading the volts. The main current is measured by the fall of volts over two sheets of platinoid, but as several large cables are connected along one edge the distribution of the current is of a very general character, and the result is not as trustworthy as that of an ordinary large ammeter.

The internal arrangements of the station being of the Siemens' type, it is natural that their armoured cable should be used in the streets, with the usual cast-iron joints and tees. For a permanent job nothing could be better, and, on the occasion of our visit, the insulation of the whole system, as shown by the usual pair of glow lamps, was excellent.

In a Paper read by Mr. Shoolbred, consulting electrical engineer to the Corporation, at the Society of Arts on Wednesday last, this type of conductor is praised as being thoroughly accessible. To get at any point, the pavement, six inches of earth, and a deal board have to be taken up; but the station being now fully loaded, the question of increasing the conductors has to be considered, and this will necessitate not only more copper, but new cables, and the taking up of the streets along the whole route. The cable is laid for the most part under the

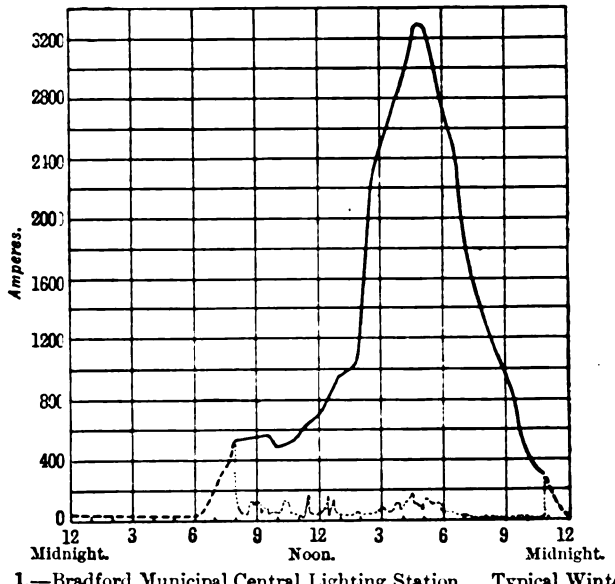

FIG. 1.—Bradford Municipal Central Lighting Station. Typical Winter Load Diagram, Dec. 23rd, 1891.

foot pavement. This, certainly, is the less expensive course; but when the whole has to be taken up for additions, it is a much greater nuisance than if the mains ran under the street. To take up the pavement is to make it practically useless for traffic, and shops and houses bordering on it are at a great disadvantage. The total length of mains is about 18 miles. The area includes a comparatively small part of the centre of the town.

The following diagrams are reproduced from Mr. Shoolbred's Paper:—Figs. 1 and 2 are winter and summer load diagrams. We have measured the load factors, and find them to be 0·282 and 0·153 respectively, taking the maximum output on each particular night as unity. The dotted lines represent the output of the battery. Figs. 3 and 4 show various costs and expenses during the last two years. Fig. 3 is not so valuable as it might be were information given as to the gradual increase of output; but we assume that this is fairly represented by the receipts.

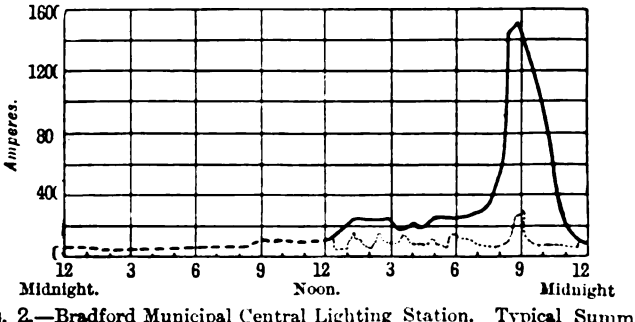

FIG. 2.—Bradford Municipal Central Lighting Station. Typical Summer Load Diagram, July 25th, 1891.

The Corporation is to be greatly congratulated on the continual decrease of the cost per unit, due, no doubt, to improvement in management under the able supervision of Mr Baynes, the introduction of feed-water heaters and economisers, which were not provided at first, as well as to the increased output. The fuel consists of "nuts" at 8s. to 10s. per ton, "slack" or coal dust at about half that price, and coke.

No reference is made in Mr. Shoolbred's Paper to the method of regulating the supply. We had been informed on more

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than one authority that the standard pressure of 115 volts was not maintained with uniformity, but an inspection of recording voltmeter cards, and information given us by Mr. Baynes, the resident engineer, about lamp renewals, does not bear out this complaint. There are seven switch-boards, corresponding with

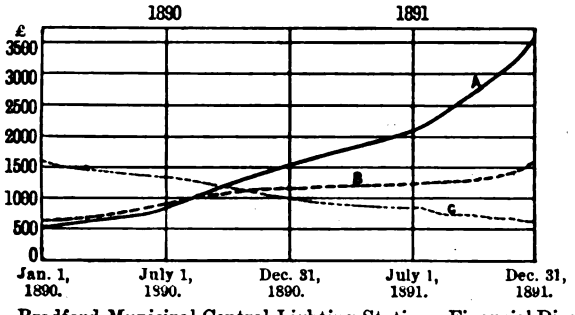


FIG. 3.—Bradford Municipal Central Lighting Station. Financial Diagram. A, total receipts. B, total expenditure. C, cost per unit.

the seven dynamos. One pole of each machine is joined to an omnibus bar; the connections of the other poles are kept on the other side of the station. A massive magnetic cut-out prevents the return of any current in case of the failure of a dynamo. Interlocking cam arrangements are provided on the switches. There are eight feeders, and the voltage at the station end at full load is about 125, the distant ends being maintained at 115, allowing nothing for distributing mains. The voltage of the dynamos is arranged to suit the highest voltage on any feeder, and resistances composed of wire rabbit netting

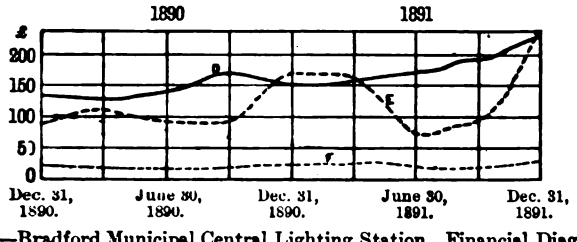
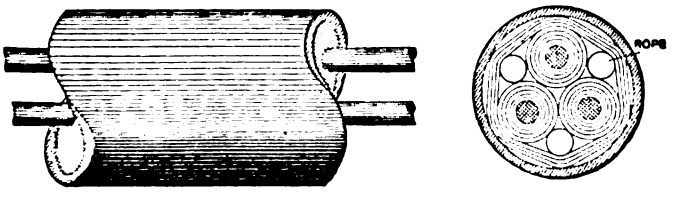


FIG. 4.—Bradford Municipal Central Lighting Station. Financial Diagram. D, wages, &c. E, coal. F, water.

is introduced into the circuits of the other feeders to bring them down to the necessary pressure. We are informed that as there is but little residential lighting, the demand is so uniform that very little of this regulation is required, except on Saturdays. A considerable portion of the supply is under three years' contracts, and it is not until these expire that the real business can be estimated. Several motors of 4½ to 10 H.P. are in use for lifts and other intermittent work. With Willans and Marshall's engines, Siemens' dynamos, switch gear and mains, Crompton-Howell batteries, and a capable engineer, the station could not well be other than a success.

THE EDISON SYSTEM OF MAINS IN PHILADELPHIA.

The cable services of the Philadelphia Edison Company, says Mr. Israel in the *Electrical Engineer* of New York, should attract the attention of all electric companies maintaining an



underground system. The Edison Companies, particularly, should examine this means of reducing their expenses. The cable employed (*see* figure) consists of the three copper conductors of the desired diameters. The Philadelphia Company uses three sizes, of Nos. 41, 80 and 160, Edison Standard Gauge. They find these sizes available for all practical cases. Two services of 160 cable are used in places where an extraordinary load is to be carried. The conductors are separated by spiral windings of hemp rope, the space between being filled in with resin and cotton-seed oil. The rope braid is wrapped around the cable, and then it is encased in a one-eighth inch lead covering. The lead is painted with a waterproof paint. The resistance is very high, and the practical problem thus solved is simply to give the conductors more rope as insulation.

BOOKS, &c., RECEIVED.

"Adressbuch der Elektrotechnik und Verwandter Zweige." (Frankfurt-a.-M.: A. Balck.)

"Journal of the Institution of Electrical Engineers," Vol. XXI., No. 97. (London and New York: E. and F. N. Spon.)

"Blow-pipe Analysis." By J. Landauer, translated by James Taylor, B.Sc. (London and New York: Macmillan and Co.) Price 4s. 6d.

"A Treatise on Physical Optics." By A. B. Bassett, M.A., F.R.S. (Cambridge: Deighton, Bell and Co.)

"A Guide to Electric Lighting." By S. R. Bottone. (London: Whittaker and Co.) Price 1s.

"Diaries of Sir Daniel Gooch, Bart." With an Introductory Notice by Sir Theodore Martin, K.C.B. (London: Kegan Paul, Trench, Trübner and Co.)

"Journal of the Iron and Steel Institute." No. II., 1891. (London and New York: E. and F. N. Spon).

"Untersuchungen über die Ausbreitung der Elektrischen Kraft." By Dr. Heinrich Hertz. (Leipsig: J. A. Barth.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, May 6th.

INSTITUTION OF MECHANICAL ENGINEERS.

7.30 p.m. Papers to be read.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Sensitiveness of the Eye to Light and Colour." By Capt. Abney, F.R.S.

MONDAY, May 9th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture, V., 2. "Recent Bacteriological and Chemical Research in Connection with the Fermentation Industries." By Dr. Percy F. Frankland, F.R.S.

TUESDAY, May 10th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "The Distribution and Measurement of Illumination." By A. P. Trotter, B.A., Assoc. M.Inst.C.E.

WEDNESDAY, May 11th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Uses and Applications of Aluminium." By G. L. Addenbrooke.

THURSDAY, May 12th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Chemistry of Gases." By Prof. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Continuation of Discussion on Mr. A. P. Trotter's Paper, "Notes on the Light of the Electric Arc;" and Paper "On the Cause of the Changes of Electromotive Forces in Secondary Batteries." By Dr. J. H. Gladstone, F.R.S., Member, and W. Hibbert, Associate.

FRIDAY, May 13th.

INSTITUTION OF CIVIL ENGINEERS.

9.40 a.m. Students' Visit to Woolwich Arsenal, the Works of the London Electric Supply Corporation, Deptford, and the Tower Bridge.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "An Instrument for Drawing Parabolas." By R. Inwards, F.R.A.S. (2) "Some Electrical Instruments." By F. H. Nalder. (3) "An Instrument for Measuring Magnetic Fields." By E. Edser and H. Stansfield.

INSTITUTION OF CIVIL ENGINEERS.

7.30 p.m. Annual Dinner at the Holborn Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The New Star in Auriga." By Dr. William Huggins, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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NOTICE.

With this week's number of "THE ELECTRICIAN" is issued (gratis) the Index to Vol. XXVIII. Complaints of non-receipt should be promptly addressed to the Publisher.

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BOOKS.

Some books, observes BACON, are to be tasted, others to be swallowed, and some few to be chewed and digested. Had he lived in our day he would have needs made a fourth class of those books which should be thrown away at once, or, better, burned. Was rubbish written in the days of BACON, or did he ignore it? *De minimis non curat lex.* If aimless and superfluous books on electricity came in driblets they could be disregarded; if in showers, they could be endured with resignation; but when they come in floods they seriously perplex the inquiring student, bewilder the intelligent public, and irritate the unhappy reviewer. Of the making of books, said KOHELETH, there is no end; and much study is a weariness of the flesh; but he probably knew no more about text books on electricity than good old BACON, who would have written a most interesting one if he had been given the chance.

The intelligent public ought, of course, to be, and is provided with more than one illustrated and readable description of the applications of electricity to the service of man in modern life. Such books ought not to be too large, for they are sure to become obsolete in a few years. A number of cheap handbooks have appeared on the bookstalls and elsewhere, generally designed to advertise the author or his wares; these appear to have met with some success, for new editions have been demanded. A new class of such books, called into existence by the spread of electric lighting, is addressed to consumers of electricity, who are presented with information about their lamps and the fittings which are connected with them, and the dynamo which generates the current, and the meter which measures it. Such books may, as BACON

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says, be tasted. *De hoc multi multa, omnis aliquid, nemo satis.* One other kind of book has been provided for general readers, and as it is represented by a single work, and that one which can be thoroughly recommended, we do not hesitate to mention its name, "Electricity" and its authoress, E. M. Caillard.

Professors and schoolmasters are naturally tempted to make use of their lecture notes by expanding them into a book form; two such books at least have done excellent service, but are rapidly being made obsolete by the advance of science. Those teachers whose unhappy task it is to train their pupils to pass examinations, naturally spend their time on making cram books by which that object may be attained. No serious objection can be taken to cram books apart from the cram system. Any one who wants to get through a certain examination has only to look out for a crammer, and the crammer will give an estimate of his own ability in a numerical form, as a percentage of successful pupils and will recommend the books. Bacon's advice about these is, of course, that they must be swallowed.

Lastly we come to the highest class, and here we may pause. There are no floods or showers here; once in two or three years a valuable book is produced; one of the "some few to be chewed and digested." In this case the proportion between the number of books and the number of men who could write them is reversed; good books are scarce, though competent writers are numerous. It is easy enough to point out men who ought to write books, but they complain that they have no time. They contribute now and then to a learned society, and there are one or two volumes of their collected papers; but one man is overwhelmed with educational work and another with manufacturing business. The profits of authorship offer no inducement whatever, and thus good books are strangled. "As good almost kill a man," says Milton, "as kill a good book;" and is it too great a stretch of the imagination to suggest that the skeleton of a murdered book may be sheltered in many a scientific cupboard?

PACIFIC CABLE SCHEMES.

Almost ever since a submarine cable was successfully laid across the Atlantic projects have been from time to time brought forward for establishing a trans-Pacific cable. A map was issued over twenty years ago by Mr. Cyrus Field showing a projected route for cables from San Francisco to Honolulu, and thence northward to Japan and southward to the Australasian group. More than one company has been formed with the object of directly connecting America or Canada with Japan or Australia; but up to the present time not a single mile of these projected lines has been laid, and it is as difficult to say now when such connections will be made as it was twenty years ago. It is easy to understand why the Government and people of the United States should desire this direct connection, because (1) of their national jealousy of submarine cables being practically a British monopoly, (2) of the desire to have such a cable laid, believing that it would increase their trade with China and Japan, and (3) of the Government desire for diplomatic reasons to have direct communication under their own control with those countries. It is not, however, easy to see why there should be in this country such a strong interest in the laying of a Pacific cable. The principal reasons urged are, firstly, increased security of telegraphic communication with our dependencies in time of war, and, secondly, the belief that the existence of such a cable would have the effect of reducing the telegraph rate from this country to the Far East.

As to the first, nothing would be easier than to cut a single or even a duplicate line of cable under that vast stretch of water, which could not possibly be patrolled by our war ships with the view of protecting the cable lying beneath. As to affording increased security of communication in time of peace, it may be pointed out that on one occasion all three of the cables to Australia were simultaneously interrupted by earthquake, while quite recently communication with South Africa was cut off by the breakage of cables on the east and west coast of that continent at the same time. As to the second point, it is quite certain that even with large Government subsidies there could not be sufficient traffic to maintain a Pacific cable even at the tariff in force, under guarantee of the colonies with Australia, namely, 4s. per word.

The fact is that there is a certain sentimental charm about the idea of completely encircling the earth with cable, due, perhaps, in no small measure, to Shakespeare's expression about "putting a girdle round the earth in forty minutes." It is difficult to see any very tangible advantage at present to this country in such an extension of submarine cable enterprise unless an infinitesimally intermittent increase of the magnetism at the North Pole be considered one.

Sooner or later, however, the combined force of sentiment and increased trade will result in a Pacific cable being laid, and as the question is constantly being brought forward in Australia, Canada, and the United States, it may be of interest to examine the different routes which have been suggested. An important factor is, of course, the enormous depths which exist in the Pacific Ocean—one sounding of 4,655 fathoms (5¼ miles) being recorded on the charts, while in another instance the surveying vessel failed to get bottom with such sounding apparatus as she had on board. In another instance, to the South of the Friendly Islands, soundings of 4,430 and 4,295 fathoms have been found close to a shoal patch of 38 fathoms. Soundings of over 3,000 and even of 4,000 fathoms are common, and for great distances no soundings have been taken. The scheme which is being most persistently advocated is that of Mr. F. N. Gisborne, the Government Superintendent of Telegraphs of Canada. We publish a map which shows all the projected Pacific cables. The route recommended by Mr. Gisborne runs from Vancouver to Unimak Island (1,500 miles), thence *northward* of the Aleutian Group to Attu Island (800 miles), and on to Japan (1,300 miles). Total cable distance, with 12 per cent. of slack 4,032 miles.

The great objection to this route is the climate of the region through which the cable would have to pass. Mr. W. H. Dall, Acting Assistant U.S.C.S. in charge of Alaska Survey, who has had nine years' experience of the climate of this part of the world, and probably knows more about it than anyone else, makes the following remarks on the subject:—

"Except for their scientific value the explorations are almost thrown away. The two principal reasons why it seems inexpedient that a cable should be laid in that region, are the climate and the absence of any local demand for the use of the telegraph or opportunities for extension by branch lines.

"The climate is characterised by the almost constant prevalence of overcast, rainy, and foggy weather in the summer season, and of the most violent and sudden storms during the equinoctial periods and at irregular intervals during the winter. *It is the most foggy and stormy region in the world.* At all seasons cyclonic storms of the greatest violence occur, with but a few hours' notice at most! *I have never heard of any vessels seeing the sun in this region, and I doubt if there are three clear days in the whole year there.*"

Then Mr. Dall gives detailed accounts, showing that on 32½ days in the year a vessel might obtain her position, while on 332½ days she could not do so. The wind attains tremendous violence, and its speed was found to be 88 miles an hour. Such storms are frequent, and come on at 15 minutes' notice, and may last an hour or three days.

Laying aside the great difficulty and risk of laying a cable under such circumstances, no plan can be considered complete which does not include the consideration of facilities for repairs. Mr. Dall asserts that there are not over 30 days in the year when a vessel might be able to obtain her position close enough to take up and repair the cable at a given point; and that at least half this clear weather would be attended with so much wind that the work would be impracticable.

To this Mr. Gisborne, in a letter to us of March 22nd last, replies as follows:—

"In the first place—*vide* Admiralty Chart of the Pacific Ocean No. 2,683, 1887—you will note that the soundings between Vancouver Island

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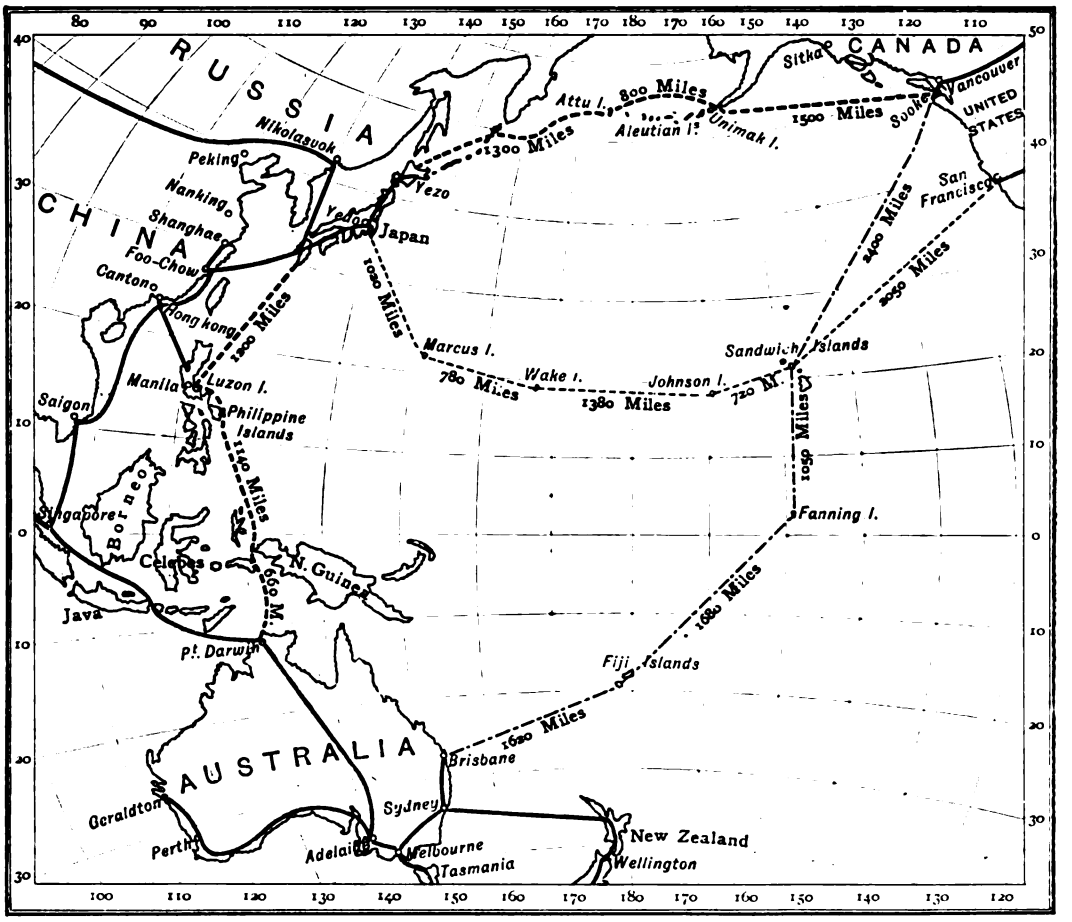
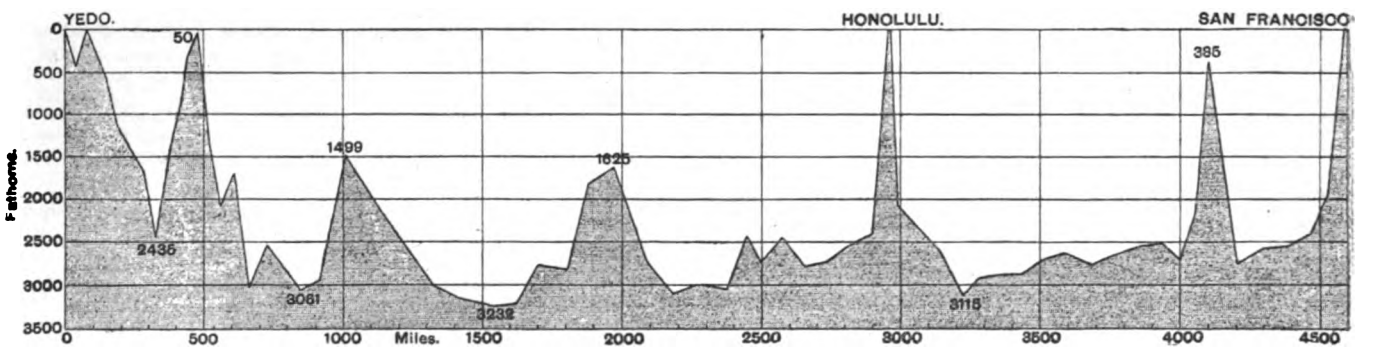
B.C., and Unimak Pass, Aleutian Islands, range from 2,000 to 2,500 fathoms, with as favourable a bed as the North Atlantic. That from Unimak Pass to Attu Island, north about (*vide* the U. S. Hydrographic Survey Chart of Behring Sea, No. 68), the maximum soundings are under 2,000 fathoms, with a favourable bottom. That from Attu Island to Kuril Straits (*vide* the Physical Chart of the World, Vol. I. of the Cruise of H.M.S. 'Challenger') the soundings are less than 3,000 fathoms, and are north of the 5,000 fathoms 'deep hollow' east of the Kuril and Japanese Islands. It was the 'deep hollow' on the direct line between the Sandwich and Japanese Islands which rendered the American project impracticable, and hence my amended possible route *vid* Johnson, Wake, and Marcus Islands, and my recommendation to the Imperial Government that they should take possession of them in like manner as Fanning and Christmas Islands had been annexed.

southern coasts of the Aleutian Islands in order to avoid the stormy weather of lower latitudes. November and March are the months of high winds, but the weather during the rest of the year is no more boisterous than the North Atlantic, although the rainfall is heavier.

"Thirdly, as to way traffic for cables. The distance between British Columbia and Japan is not greatly in excess of that between New York and England, and at Yezzo you are in direct communication with the four hundred millions of Japan and China *versus* the four millions of Australians *vid* the Sandwich Islands and Fiji Islands route, and be it remembered that *vid* Japan and Manilla Australia can be reached by 150 miles shorter lengths of cables than *vid* the southern route. I have no hesitation, therefore, in re-affirming my conviction that the northern route is the most feasible, and the only one that offers a reasonable prospect of becoming a commercial success."



Map showing the routes of the various projected Pacific Cables. (The figures give distances and not cable lengths.)



Section of bed of Pacific Ocean from San Francisco to Sandwich Islands, and thence to Japan. Vertical scale approximately 280 times greater than horizontal scale.

"Secondly, as to weather interferences with cable repairing. Mr. Dall's experience was during the coast survey of Alaska, with its densely foggy climate; but from Dr. George Dawson, F.R.S., one of our late Fur Seal Commissioners, who has lately returned from a three months' cruise throughout Behring Sea, I learn that although as a rule the sky was overcast they had no difficulty in obtaining observations or determining their exact position—that dense fogs do not occur as on the North Atlantic, and that when the sun is obscured the high peaks of the Aleutian Islands are nearly always available for the requirements of navigation. It is also notable that the steamers of the Canadian Pacific Railway take the northern route between Japan and British Columbia, and frequently sight the

As to Mr. Gisborne's comparison of the four hundred million of Japanese and Chinese with the four millions of Australians, in regard to telegraph traffic, a parody of Tennyson's line may be permitted—

"Better fifty men from Europe than a million in Cathay,"

as it is absolutely certain that not one in a million of the natives of Japan and China ever send a cable message, and the time will probably have to be reckoned in centuries before any considerable revenue is derived from this source.

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Again, in regard to Mr. Gisborne's references to the soundings on his projected route, it must be pointed out that there are vast stretches over which the latest Admiralty charts show no soundings whatever, and this is particularly the case to the north of the Aleutian Islands. As, however, Mr. Gisborne produces some evidence controverting the report already referred to of Mr. Dall, it may be worth while to give the following extracts from the sailing directions for the North Pacific Ocean.

'*Aleutian Archipelago.*—The prevalence of fogs, the rapidity and uncertainty of prevailing tides, make an approach to any of the passes between the Aleutian Islands hazardous in the extreme."—Commander de Long, U.S.N.

'On all these islands traces of volcanic activity are evident. On many of them there are volcanoes in activity, and some, as for example Ounimak, are subject to continual volcanic eruptions and shocks.

"*Fox Islands.*—Rurick or Unimak Strait, through which Kotzebue passed in 1817, separates Unimak from the Krenitzen Isles to the southward. Its narrowest part is about 9½ miles broad. The currents are very violent in it, being variously stated to run at from three to six knots.

"*Kurile Islands and Strait.*—Kurile Strait, the passage between this Cape and Shumshu, the N.W. Kurile Island, is about eight miles broad, and very dangerous on account of the strong currents and the sunken rocks on either side, which narrow it to a width of three miles. The depth in this Strait is 10 to 20 fathoms, and from its east end a W.N.W course leads safely through.

"The name Kurile is derived from the Kamtchadale word for "smoke," the volcanic islands having been seen from Lopatka. The islands are all surrounded by fields of sea-weed. Our acquaintance with the configuration of the Kurile Islands may be considered as tolerably complete. This result was one of the most difficult problems in hydrography. The fog in which the group is constantly enveloped; the violent currents experienced in all the passages or straits separating them; the steepness of their coasts and the impossibility to anchor near the land, are such formidable obstacles that it tries to the utmost the patience and perseverance of the mariner to acquire any knowledge respecting them.

'The south-west anti-trade or passage winds, which occupy all the northern part of the ocean, will require still fewer words. It has all the general characteristics of the similar wind in the Atlantic, and perhaps is more persistent on the western side of the ocean. But here it is very much affected by the vast area of land it passes over, and reaching the ocean as a very dry and cold wind it has a correspondingly severe effect on the climates of the northern parts of Japan, Saghalin, the Sea of Okhotsk, &c., which are proverbially inclement, and for a long period of the year completely ice-bound.

"On reaching the open ocean, where the great return stream called the Japanese Current runs to the north-eastward, carrying with it the warmer water of the tropical latitudes, this cold and dry wind so condenses the warmer vapours which hang over the current that they are condensed into almost perpetual fogs. A similar and well-known region is found in the vicinity of the Banks of Newfoundland, but here these fogs extend far to the westward and envelope more or less continually the extensive ranges of the Kurile and Aleutian Islands. Dissolving these vapours, and acquiring further humidity and also increased temperature in its further progress to the eastward and north-eastward, it is found on the Alaska coasts as a warm, rain-bearing wind, which deposits its abundant moisture on the coasts and islands of that comparatively unfrequented region."

In the light of such statements from eminent authorities on the subject as are given above, there is, to say the least, very small probability of the northern route being chosen for a Pacific cable. It may further be said that there is no settled population in any of the Aleutian Islands, and that any revenue derivable from whalers or sealers telegraphing is not worth consideration, and there is no probability of an adequate subsidy being obtained from Japan.

As there are no islands available for stations in a direct line between either Vancouver or San Francisco and Japan, and as the distance from San Francisco to Yokohama (4,750 miles) is much too great for a single stretch of cable, the only other route worth considering is what is called the southern route—that is to say, from Vancouver or San Francisco to the Sandwich Islands, a distance of 2,400 and 2,050 miles respectively; thence to Johnson Island (720 miles), on to Wake Island (1,380 miles), Marcus Island (780), and up to Japan, 1,020 miles, a total of 6,000, or with 12 per cent. of slack, 6,500 miles; or from Sandwich Islands to Fanning Island, 1,050 miles; thence to the Fiji group, 1,680 miles; and on to Brisbane, 1,620 miles—a total of 6,750 miles. The above figures of the distances (not cable lengths) between the places named are Mr. Gisborne's, who, in his estimates, has allowed 12 per cent. for slack; but in view of the great depths of water at least 15 per cent. would be necessary. Almost all of the smaller islands in the Pacific available for intermediate stations are surrounded by belts of coral, so that the very greatest care would have to be taken in selecting landing places, otherwise the shore ends would be very quickly destroyed.

In view, however, of the fact that the Australasian colonies will probably eventually subsidise a Pacific cable, and that subventions might be obtained from Great Britain and France in respect of Fiji and New Caledonia, it is almost certain that the last route described will be the one ultimately adopted. In this case the cable distance, allowing 20 per cent. of slack, will be as nearly as possible 8,400 miles, and the cost, at £250 per mile, which is a low figure in view of the large core and large amount of gutta-percha necessary to get a moderate speed over such very long sections, would be somewhere in the neighbourhood of two millions sterling. It would certainly be necessary to maintain at least one ship to restore communication in the event of interruptions, at a cost per annum, say, of £15,000. There would be five stations costing, say, £2,000 a year each—total £10,000. In the case of a new company with so extended a stretch of cables laid in such great depths of water, 5 per cent. per annum should be set aside to provide for the renewal of the cables, at all events until a respectable reserve fund had been built up. This would require £100,000 per annum. Add to this £5,000 yearly for expenses of management, and we find that the working expenses and reserve would come to £130,000, while to pay a dividend of 5 per cent. a revenue of £230,000 would be necessary. Assuming—which is, however, assuming a great deal—that subsidies to the extent of £50,000 per annum for 20 years could be obtained from the various Governments interested, a revenue from cable messages of £180,000 would be required. As a matter of fact, assuming that all the Japan, China, and Australia traffic to Canada and the United States went by the proposed route, this would be very considerably more than the present revenue derived from that traffic. Mr. Henniker Heaton, in a Paper read before the Society of Arts in February, 1890, estimated that if a Pacific cable were laid traffic might profitably be carried from England, *vid* the Atlantic, North America, and the Pacific to Australia, at 1s. per word. It is only necessary to quote such a statement to show its absurdity. The present rate from England to America alone is 1s. per word. Assuming that the Pacific cable got, out of a shilling rate, 4d. per word, and carried ten paying words every minute of the year, the revenue would only be £87,600, whereas in practice the great bulk of the traffic has to be carried in eight or ten hours out of each twenty-four.

When some one told Canning that war was inevitable sooner or later, he replied, "In Heaven's name then let it be later," and his remark applies to a Pacific cable. The greater the time that is allowed for the opening up of China and Japan to commerce, and for the increase and multiplication of the Australasian population, the better will it be for the shareholders whose money is subscribed for this enterprise. This does not, however, apply to this extension being carried out by the existing companies, for obviously, with their large reserves and power of issuing debenture stock in a few years at 3½ or 3¾ per cent.—their existing Four per Cent. Stock being at a considerable premium—they are, or rather will be, in by far the most favourable position for handling the matter when the time to do so shall be judged to have come; while their great experience of cable-laying, and the use of their ships in taking a line of soundings for the cable, would be important factors in the durability of the cable, and would result in less frequent repairs or renewals.

NOTES ON THE LIGHT OF THE ELECTRIC ARC.*

BY ALEXANDER PELHAM TROTTER, B.A.

(Concluded from page 689.)

Two other kinds of arc are the lighthouse and the search-light. A very elaborate set of experiments was carried out in 1878 at Chatham under the direction of the Royal Engineers Committee, by Major R. Y. Armstrong, Lieutenant G. Bowker, Lieutenant P. Cardew, Lieutenant L. Darwin, Lieutenant G. A. Carr, assisted by Lieutenant R. White and Captain Abney. Ten dynamos, six lamps, six projectors, and five kinds of carbons were tested; photometric measurements were made, and photographs were taken

* Paper read April 28, 1892, before the Institution of Electrical Engineers.

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both facing the crater and at right angles to it. From the photographs the area of the crater could be determined. The candle-power per square inch seemed to vary in an indefinite way between 76,000 and 25,000 candles per square inch.

The photographs taken from the side give a very good idea of the position of the carbons and the small obstruction of the negative carbon when a search-light is properly arranged. Finding that so complete an examination of search lights has been made, the author has not proceeded with the experiments which he had intended to carry out on this kind of lamp. He had some difficulty in finding this report, which was intended for Government use only. He was allowed by Major R. Ruch to examine a copy at the Horse Guards, and on making application through him to the Inspector-General of Fortifications the report was allowed to be made public. Instead of attempting to abstract this very interesting research, the author has presented the copy to the library of the Institution.

By permission of Mr. Inglis, secretary to the Trinity House, the author was permitted to examine the working of the St. Catherine's Point lighthouse at the beginning of the present month, and to have the machinery run during the daytime. The magneto-machines and lamps are the same that were used at the South Foreland in 1884 and 1885. Alternating currents from 180 to 300 amperes are used, the volts at the lamp are only about 35 to 38. Sir James Douglas's fluted carbons of 50mm. and 60mm. diameter, are used, the smaller size being employed during clear weather. Fig. 8 gives a section of one of these carbons full size; they have a graphite core. The conditions are altogether different from the continuous-current arc which has been described. It was found during the South Foreland experiments that a short arc gives more light than a long one. It must be remembered that the horizontal light is the most useful, although in a large lantern a considerable angle is utilised

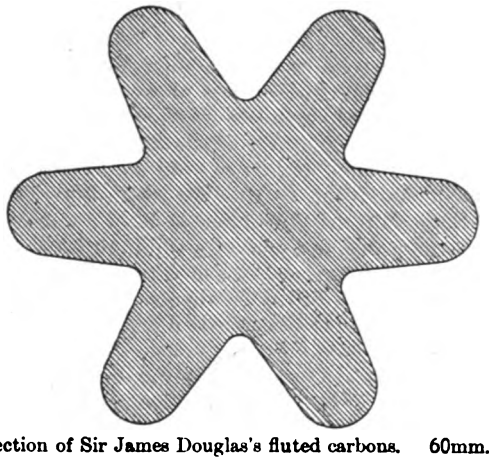

Fig. 8.—Section of Sir James Douglas's fluted carbons. 60mm. (full size).

by the lenses. A large alternate-current arc is very unsteady, the flame burns away the carbon in a very irregular manner, and when round carbons were used a hollow crater was formed at the end of each. The walls of the crater would give way, and cause great variation in the light. By the use of fluted carbons little, if any, hollowing takes place, and the light is more uniformly emitted. It seems probable that since each carbon is only at a high state of incandescence during half a period, that a short arc gives more light, because the carbons keep each other warm. The same amount of radiant energy may be given off with a long arc and a short one, but when the chilling of the negative is reduced a greater proportion of the radiation will be in the form of light. With a long alternating arc the flame wanders round, and is blown violently sideways, and the crater therefore tends to be shifted to one side of the carbon. The distance between the carbon is only $\frac{1}{16}$in. to $\frac{1}{8}$in., and as they are by no means flat it is the exception that any interval can be seen between them.

The author understood that an optical apparatus was provided for projecting the image of the arc on the side of the lantern, for the purpose of keeping the carbon points in the focal plane of the lenses. He found no such instrument was in use at St. Catherine's Point, but a very satisfactory image was thrown by the object glass of a telescope. The distances were arranged so that the image was full size. The shape changed so quickly that it was impossible to draw the image with great accuracy, and attention was paid only to the outline of the carbons and of the crater. The outlines in Fig. 9 are reproduced from a series of 12 tracings made at intervals of half a minute. Fig. 10 shows an irregular interlocking of the two carbons. This does not appear to have any connection with the flutings of the carbons, and the author has noticed it on several occasions, both at the lighthouse at the recent Naval Exhibition and at St. Catherine's Point. A glance at these tracings shows that only a very small portion of the true light-giving surface is visible, owing to the shortness of the arc.

The areas of the crater on the tracings was measured by a planimeter, the tracing point being taken ten times round. The mean area of Fig. 9 is 0·2087 sq. in., and the mean of Fig. 10 is 0·146 sq. in. The interlocking form of crater appears therefore to give about 30 per cent. less light. The candle power for 240 amperes, according to the measurements made at the South Foreland in 1884 and 1885, is about 16,000 c.p., giving about 75,000 candles per square inch if the light were entirely due to the crater. The area of the yellow and orange-coloured parts of the carbons was very difficult to estimate, but it was very much greater in proportion to the true crater than in a continuous-current lamp taking 10 to 20 amperes. Taking these parts as exposing about four times the area of the crater, and giving a one-eighth of the light per square inch, the crater alone may be taken as giving two-thirds of the whole, or about 50,000 candles to the square inch. This agrees fairly well with the result already given for the measurements at Finsbury.

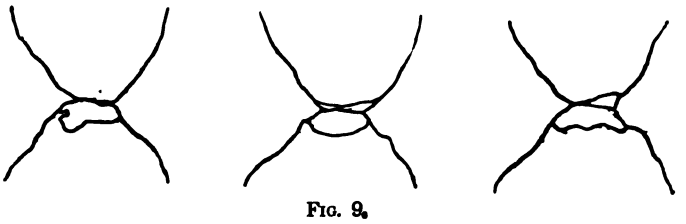

Fig. 9.

It was found, during the South Foreland experiment, that 40mm. cylindrical carbons became red hot throughout their whole length when 300 amperes were passing. The fluted carbons, measuring 60mm. over, have a sectional area equal to that of a cylinder about 46mm. diameter, that is $2\frac{1}{2}$ sq. in.; but the cooling surface is about 50 per cent. greater. Larger carbons would probably burn yet more irregularly, and yet it seems very desirable to increase the light during foggy weather. If the ends of the carbons could be maintained conical, all the light-giving surface would be usefully employed. A carbon which is more and more refractory towards the centre suggests itself; but even at present the consumption is from $1\frac{1}{2}$ to $2\frac{1}{2}$in. per hour, and modification can only be made in the direction of less refractory material. The flame might be made to spin round the carbons under the influence of a magnetic field; but the simplest plan seems to be the revolution or gyration of the carbons about a common axis, their centres being slightly displaced. In order to obviate sliding contacts, a gyratory motion would be the best. The power of the St. Catherine's Point Lighthouse has been called 6,000,000 to 7,000,000 c.p. This would require an area of crater of about 1 sq. ft.

The foregoing considerations about continuous-current arcs point to the value of a long arc, a small, and, if possible, a pointed negative carbon; but these must without hesitation be sacrificed to perfect steadiness. For outdoor work the uniformity of distribution is not much affected by the shadow of the lower carbon; indeed, it may, perhaps, be advantageous, for there is a fair amount of stray light immediately beneath an arc lamp; and if the lower carbon could be dispensed with there would be an overpowering illumination, which would make street lighting much more irregular than at present, unless very high posts were used. But for railway stations and for such places as the British Museum reading-room some improvements might be made in this direction. Experiments have

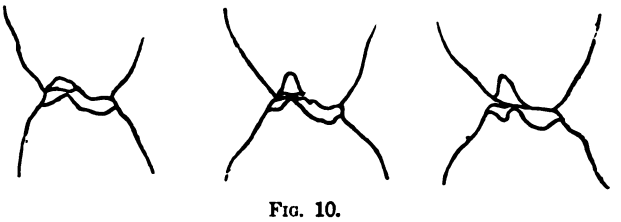

Fig. 10.

been made by W. S. Stanley (*Electrician*, Vol. XXVI., p. 646) with a carbon rod surrounded by a carbon tube arranged pointing downwards, and the arc has been made to travel round by magnetic rotation. The rod should be positive, as the end surface of the tube would be too large to keep incandescent unless with a very large current. The Jamin candle, a modification of the Jabochkoff, and the Rapieff and Hedges lamps, are examples of efforts in this direction.

[1] Several attempts have been made to improve the arc by adding volatile substances, or by introducing gas through a hollow carbon. The most successful of these appears to have been the Saunderson method of using hydrocarbon by means of a wick, but nothing has been heard of this for some time. The only good effect that can be expected is the production of a long arc which will reduce the shadow of the lower carbon; and it is likely that the temperature of the crater will be reduced by the presence of any substance less volatile than the best carbon.

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With a scientific but misguided regard for truth, the candle-power of arc lamps has been reduced to its "mean spherical" value by many authorities. An easy way to arrive at this is to cut out a piece of card to the shape of a candle-power diagram, such as Figs. 1, 2 or 3. By balancing this on a pencil, on a line parallel with the perpendicular axis, the centre of gravity may be found. The area may be measured with a planimeter, or by comparing the weight of the card with that of the rectangle out of which it was cut, or by treating the curve as being composed of half an ellipse and part of a parabola.* Then, measuring the distance of the centre of gravity from the axis, and multiplying this by 2π times the area, the solid contents of the figure of revolution of the curve about its axis are obtained. The mean spherical candle-power of the arc is equal to the radius of a sphere, having the same solid contents. As so little light is emitted above the horizontal, it would seem quite as useful to take the mean hemispherical candle-power. But we not only learn nothing fresh, but are likely to be misled, for a light giving the same mean spherical candle-power would not be nearly so useful as an arc. The mean spherical candle-power has been found by M. Rousseau by plotting to rectangular co-ordinates.† But the method is not much easier, and it seems better to retain the polar curve, which has a geometrical meaning.

Since there is little or no difference in the light-giving properties of arc lamp carbons, the various qualities differing mainly in homogeneity and rate of burning, and since there must be a definite relation between the watts expended and the area of the crater or the candle-power, it seems preferable to denominate the size of arc lamps by the number of watts expended. There is no reason why the maximum candle-power at the best angle should not be given, if the candle-power be mentioned at all; but the carbons should be very carefully centred, and the test should be made, either with several photometers simultaneously, or with a lamp revolving like a meat jack. The nominal 2,000 candle-power, which 10-ampere arc lamps are sometimes supposed to give, is a perfectly unjustifiable convention, and has been very properly characterised as "a fine old crusted lie."

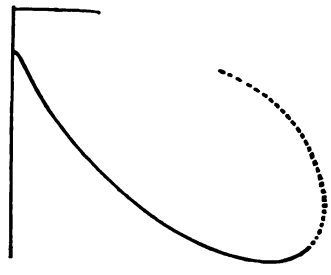

Fig. 12.

It might be imagined that, since an ordinary opal globe surrounding an arc lamp does not appear to differ greatly from a uniformly luminous sphere, the candle-power at different angles would be very much more uniform. This is not the case. Fig. 12 has been derived from the measurements of the illumination on the surface of the street by an arc lamp in Cornhill, an opal globe being used; the dotted line is assumed. Fig. 13 is a similar curve, derived from measurements made in Queen Victoria-street with arc lamps enclosed in moulded glass.

Owing to the difficulty of comparing the light from an arc lamp with the light of a candle, on account of the difference of colour, it has been a common practice to make photometric measurements with red and with green glasses, and elaborate tests have been made by Prof. Nicol and others throughout the whole range of the visible spectrum. The red and green glasses allow rather more definite readings to be made; but by a little practice with a photometer, which allows very free and rapid changes to be made by the oscillation of a lever or a handle, very much greater accuracy may be obtained than with an instrument in which a screen or a lens has to be moved on a slide until a balance is effected. But the green and red measurements having been taken, no one has yet suggested what is to be done with them; neither the mean, the sum, nor the product, has any physical meaning, and the two readings are generally given side by side. For purely scientific work, where the light is treated as radiant energy, either the whole spectrum should be measured and compared with a standard, or the luminous rays should be carefully separated from the dark heat rays, and the radiation measured as a whole. Such measurements have been made by H. Nakano and by Louis B. Marks,‡ and form a very valuable contribution to our knowledge of the efficiency of the arc.

* Area of ellipse = minor axis × major axis × $\pi/4$. Area of parabola = base × 2/3 height.

† Eric Gerard, "Leçons sur l'Électricité," Vol. II., p. 298.

‡ American Institute of Electrical Engineers, May 21, 1890. *Electrician*, Vol. XXV., p. 150.

It has been shown by M. A. Crova* that the portion of the spectrum lying near $\lambda = 582$ gives a true measure of the total candle-power of a light. Prof. E. L. Nichols† finds $\lambda = 600$ to be the position. For a considerable range of temperature the ratio between the different intensities of this part of the spectrum is practically identical with the ratio of the candle-power of two lights.

The use of the green and red measurements, besides facilitating the work of the photometrist, is to compare, in a rough way, the whiteness of the light under observation with a standard light. The measurements of M. de Nerville‡ afford some information as to the colour of the arc lamps at the Hippodrome, the glow lamps at the Opera House, and the gas lighting at the Post Office at Paris. But this information can be obtained only in the arbitrary terms of the ratio of the red reading to that taken with the green; when these two are equal, and the ratio is unity. This was the case with the Edison lamps at the Opera House, but it tells us nothing. A complete luminosity curve for each glass throughout the spectrum would be required to explain these readings; but even then the resultant luminosity curve could not be derived. Some idea of the quality of the light thus measured may be determined by comparing the ratio of the red and green components of some standard light. Such a comparison may be made with measurements made by M. de Nerville on the illumination produced by bright sunlight shining on a window with white blinds. The ratio of green to red in this particular photometer was about 3·5 to 1 for sunlight at four o'clock in the afternoon on May 1, 1890.

Captain Abney has made many investigations on the colour of daylight, and a chapter is devoted to this in his popular book on colour measurement and mixture. In searching for a standard light of uniform colour he found nothing to equal that which is given from the crater of an arc. This is very satisfactory to electrical engineers, but it gives no definite information as to the real quality or degree of whiteness of the light. The popular idea, and one which is very firmly fixed, is that arc lamps give a bluish light, sometimes rather violet, that it shews up certain colours in a sickly or unnatural manner; and there is a widespread belief that it not only acts injuriously on the complexion, but pierces cosmetic embellishments. These ideas are of so serious a nature that the

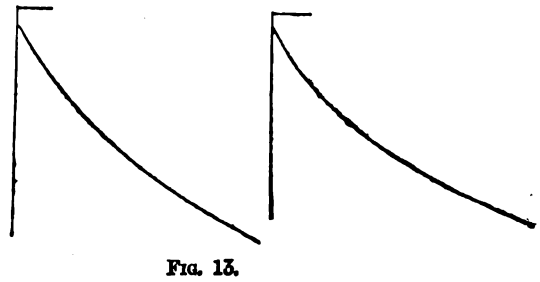

Fig. 13.

author ventures to discuss the quality of the light of the electric arc; since, although it is not a strictly electrical matter, it has a rather important aspect, in so far as it is a more or less unpopular feature of electric lighting.

The only standard of pure white light which we have is that of the diffused light of a summer day. Artists are familiar with the fact that direct sunlight is yellowish§, even on the clearest days; and that a blue sky, on the other hand, gives distinctly blue light, and that both of these must be avoided, or a picture painted under such lights will appear too cold or too warm when hung in a diffused light. Captain Abney has found that at different seasons of the year and at different times of the day very considerable changes occur in the colour of sunlight, owing to the absorption of bluish light by the atmosphere. It does not, however, appear impracticable to the author to fix on a fairly typical degree of whiteness, such as that of chalk, whiting, or alumina exposed to diffused light in summer time. A luminosity curve of the spectrum of such light would be a standard. Compared with such a white, or indeed by a very rough comparison with ordinary daylight in clear weather, the arc gives a distinctly pale primrose light, rather warmer than straw-yellow, and, to the author's eye, distinctly yellowish, in spite of the pale violet flame of the arc, which with inferior carbons occasionally flares up at irregular intervals. It is no use telling an unscientific person

* Electrical Congress, Paris, 1889.

† American Institute of Electrical Engineers, 1890. *Electrician*, Vol. XXV., p. 225.

‡ Société Internationale des Electriciens.

§ Dr. W. J. Russell and Capt. Abney, on the other hand, say "The light from a sky which is cloudy has very much the same composition as sunlight itself, as we have repeatedly proved." "The proportion of blue rays in sunlight near mid-day in May is very nearly the same as the standard light" ("the white hot crater in the positive carbon pole of the electric light").—"Report on the Action of Light on Water-Colours," c. 5453 1888, pp. 23 and 69.

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that the light is not blue but pale yellow; he will answer, "it appears to me to be blue or violet, and, therefore, to me and to ninety-nine people out of a hundred it *is* blue or violet."

Three reasons can be brought forward to explain this optical illusion. After dusk we are accustomed to the use of strongly yellow and even orange-coloured light of gas, lamps, candles, or glow lamps; and our own idea of whiteness is lowered. The whitest thing that we can see is a sheet of white paper, which is, of course, no whiter than the yellow light of the lamps; we imagine that it *is* white, and thus a false standard of white is obtained. When a really whiter, though not perfectly white, light is introduced, it naturally seems to be bluish compared with the false standard of white. Whether our idea of white really becomes altered is a psychological question which it would be out of place to discuss in the present Paper. Secondly, after dusk, the blue-seeing nervous elements of the eye (on the Young-Helmholtz theory) are allowed to rest, while most of the work falls upon the red and green-seeing elements. These latter become wearied, while the former are in a more highly receptive condition than during the day. As soon as a light containing a tolerable proportion of blue light is seen, it naturally appears to be more blue than white. The third suggestion is based upon a result of Captain Abney's researches, which show that for the most feeble illuminations no colour can be distinguished, and that the first colour which can be discovered is blue. He finds, and is supported in this by Lord Rayleigh, that the faintest light appears of a greyish-green colour, and Captain Abney attributes the apparent colour of moonlight to this cause. The author does not attach much importance to the application of this phenomenon as an explanation of the colour of the light of arcs, but it is worthy of record in this connection. When the eye passes gradually from daylight into electric light without seeing any distinctly yellow light, the sensation of blueness is rarely, if ever, observed.

It would be easy to humour this optical illusion, as is done at the British Museum reading-room, by the use of screens of yellowish glass; but a much more important consideration is the value of the arc light for the proper discrimination of colours; and though it is found in dye works that most colours can be matched with a good 15 or 20-ampere arc, there appears to be no reason why a perfect reproduction of a standard daylight quality of whiteness should not be obtained, at all events with arc lamps if not with glow lamps. The public would not be ready to believe it, they would call such a light bright blue; but that does not matter much. As the idea did not occur to the author until the autumn of last year, he has been unable to make experiments with summer daylight, but as it would be a misfortune if it were patented, he takes the present opportunity of describing the principle.

The full line in Fig. 14 is the luminosity curve for the light of the positive pole of an arc as determined by Captain Abney. The horizontal scale is the length of the spectrum, and the letters refer to the well-known lines. The ordinates are a measure of the brightness of each part of the spectrum. The dotted line is the luminosity curve for sunlight in May, from the same authority. Fig. 15 shows the difference between these two curves. The portions which lie below the horizontal line represent the excess of orange and greenish rays in the arc, and the portion which lies above the line represents the deficiency in blue rays. Such a deficiency has the same effect on the eye as an excess of yellow, and the whole effect is distinctly more yellow than sunlight. The light of a glow lamp at ordinary incandescence is almost exactly the same as that of gas. Fig. 16 gives the luminosity curves of arc and gas, and Fig. 17 shows the difference which, when the curve of gaslight is reduced so as to fall wholly within the arc curve, as in Fig. 16, consists of a deficiency which increases rapidly towards the blue.

Assuming ideal daylight to be rather less yellow—that is, more blue than sunlight, the dotted curves in Fig. 18 have been drawn from Capt. Abney's curves of sunlight and the light of blue sky. One-third of the difference between sunlight and blue sky has been added to the sunlight. The dotted curves are of the same kind, but the ordinates have been reduced. Fig. 19 shows the differences. Compared with the strongest daylight curve, the arc has a marked excess of orange, and a deficiency of greenish blue. With weaker daylight there is a greater excess of yellow, and with the weakest light shown, since it lies almost entirely within the arc curve, there is practically no deficiency in the blue.

There are two different ways in which this result may be practically used to produce artificial daylight. A glass or other medium may be tinted with stains or dyes, which will absorb the proper amount of yellow and red light, and the lamp may be surrounded by such a medium; or a reflecting screen may be painted with such a colour that this yellow light may be absorbed, and the white light alone may be reflected. Blue glass chimneys are used for microscope work, and are occasionally used for reading lamps with the view of giving a more agreeable light. The lowest curve but one in Fig. 19 has a small deficiency of greenish blue, this would affect the eye as a very faint yellowish tinge. If the excess of yellow in the rest of the spectrum could be corrected, a very close approximation to daylight would be attained. About one-third of the useful power of the light would have to be sacrificed. With gaslight or glow

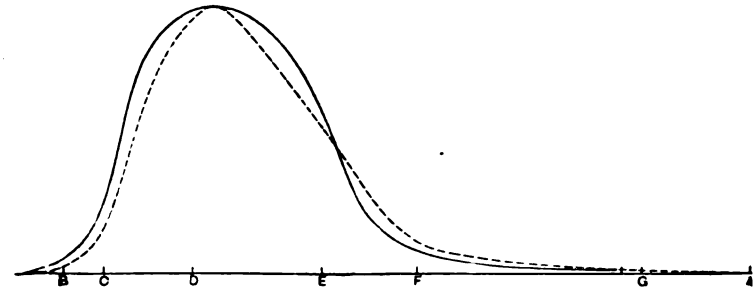

Fig. 14.—Arc and Sun.

lamps more than two-thirds of the light would have to be absorbed in order to reproduce the effect of daylight.

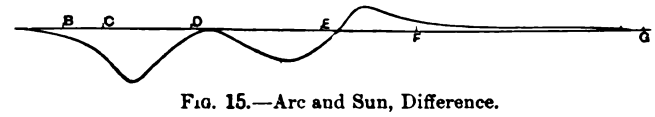

Fig. 15.—Arc and Sun, Difference.

Quite apart from considerations of colour-matching, the use of a white light ought to be good for the eyes, since all the nervous

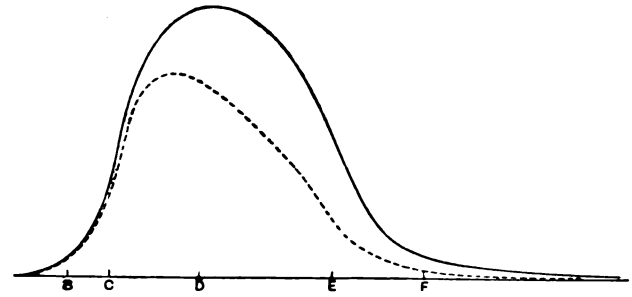

Fig. 16.—Arc and Gas.

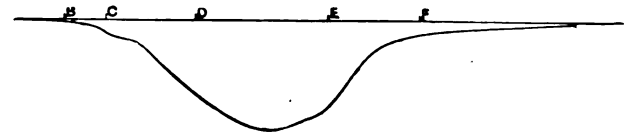

Fig. 17.—Arc and Gas, Difference.

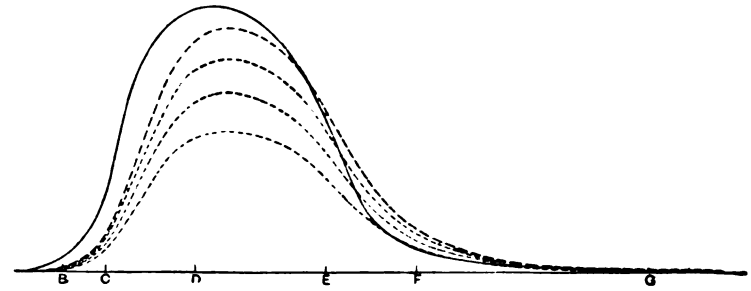

Fig. 18.—Arc and Daylight of Different Strengths.

elements would be equally excited as in normal daylight. The author has not yet completed his experiments on coloured shades,

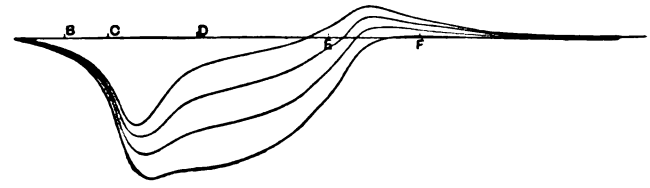

Fig. 19.—Arc and Daylight, Differences.

but has produced coloured screens which, when illuminated by lamplight, reflect a light which cannot be distinguished from white when compared with daylight. It does not follow that the light

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is identical with daylight; but he hopes to follow up the matter during the summer.

The following measurements of red and green light from different sources have been made by Prof. L. Weber, of Breslau,* taking incandescent platinum as unity. Taking the Violle platinum unit at 18·5 standard candles, the author has converted them into candles per square inch and candles per square centimetre, and has added six other sets, with white light only, from his own observations.

	C.p. per sq. in.		C.p. per sq. c.m.	
	Red.	Green.	Red.	Green.
Platinum	120	120	18·5	18·5
Sun's disc	487,000	1,000,000	75,300	155,000
Sky, near sun	120	120	18·5	18·5
Albo carbon on edge	73·5	60·7	11·4	9·4
White paper, horizontal, exposed to summer sky, noon	16·5	35·2	2·56	5·45
White paper, sun 60° high, paper facing sun	8·25	17·2	1·28	2·67
Albo carbon flat	10·5	8·7	1·6	1·35
Argand	6·8	5·24	1·05	·82
Black velvet, summer sky, noon	·0333	·07	·0052	·0108
White paper, reading without straining	·0018	·0024	·00028	·00037
	White		White.	
Sperm candle	2		·31	
Moon, 45°	2		·31	
„ high	3		·46	
Batswing (whole flame)	2·25		·35	
Methven standard	4·3		·666	
Crater of electric arc	45,000		7,000	

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 23, 1892.

The Electrical Control of Street Car Motors.—The methods of electrically controlling street car motors was the subject of a Paper read before the monthly meeting of the American Institute of Electrical Engineers last Tuesday evening by Mr. H. F. Parshall. While at first sight this appears to be a matter of secondary importance in street car work, it was pointed out that in reality it is one of the most important features to deal with, as the electrical design of the motor in no small degree depends upon the way in which its control is effected. Mr. Parshall's experience has been very extensive with a single class of motors, namely, the type using commutated fields. He has been connected with the Sprague and Edison companies for several years, and has had no small part in the designing of the motors that have been put upon the market by those companies. The particular advantages of the commutated field method were shown by Mr. Parshall to be that with a limited number of pounds of copper, or in the case of street car motors with a limited space available for field-magnet windings, it is possible to adjust the magnetising force of the field coils so that the rate of doing work of the motors may be made to correspond with the rate this work is required by the cars for various speeds and conditions of track. The precision with which this adjustment can be made depends upon the number of separate field-magnet coils, but the complications arising from using too many coils has shown that the practical limit is reached with about three separate spools on each limb of the field. It is the opinion of many practical street-car men that with even three coils the car winding is much too complicated for everyday use, as considerable trouble is experienced with the contacts.

The Thomson-Houston-Edison Consolidation.—It is announced this week that the Thomson-Houston Company has transferred the manufacture of its large power generators from its factory at Lynn, Mass., to the Edison Works at Schenectady, N.Y. This is one of the results of the recent consolidation of the two companies, and shows that, although there are two separate companies with distinct sets of officers, the management is really in the hands of a single individual. Mr. C. A. Coffin is generally credited with the virtual control of the entire business of the consolidated companies, and it is evident that the business of the two companies is being conducted along very different lines from what it was six months ago.

The Edison Filament Patent.—The Edison filament patent case was called last Tuesday in the Circuit Court of Appeals in this city, but owing to the non-appearance of one of the judges the case was postponed until Monday, the 25th inst. The case will be heard before Judges Lacombe and Shipman, and it is understood that both parties to the suit are ready with their respective sides of the case. Since the decision by Judge Wallace in the lower court, the consolidation of the Edison and Thomson-Houston companies has taken place, and this gives a somewhat different standing to the case from the point of view of the smaller manufacturers, since the interests of these two big concerns are now identical.

Telephone Patents.—The daily papers for the last few days have contained rumours of forthcoming important patents on the telephone. It seems that three patents will be issued by the U.S. Patent Office on May 3rd to Thomas A. Edison. These patents were assigned by Edison to the Western Union Telegraph Company, and this company in turn has disposed of its interest in the patents to the Bell Telephone Company. The patents are said to be fundamental in their nature, and to pertain to carbon transmitters. It is likely, however, that they have been in the Patent Office for a number of years, since it is well known that Edison has done no telephone work for a long time. The effect of the rumours on the Stock Market has been very marked, as Bell Telephone stock has very materially appreciated in value.

Electrical Literature.—A new book on power transmission is announced by a prominent publisher. The authors are W. M. Schlesinger and T. C. Martin. Mr. Schlesinger is at present connected with the Edison Company, and has had a wide experience in the transmission of power, especially for mining purposes; while Mr. Martin is well known as the present editor of the *Electrical Engineer*. Many American readers are looking forward with interest to the publication of this book on what is now the foremost topic in American electrical circles. I might mention here that the announcement of a work on electric traction by Mr. Reckenzaun, in England, has created considerable interest in this country.

GERMAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

On Thursday evening, April 17th, Mr. Ferranti visited the Cologne central station, and found the machinery, and especially the horizontal Sulzer engines which you illustrated in your issue of November 13, 1891, "very beautiful." On the whole he seems to have taken away with him a good impression of the station. Had he come about half an hour earlier he could have seen the 500 H.P. and the 125 H.P. running parallel for the purpose of switching the day load of the latter to the larger machine. During the recent bright and fine weather the consumption has been very small, and therefore the machines only run parallel when one is going to replace the other. It may be stated, however, that the engineer of the station, Herr Clarence Feldmann, ran the two 500 H.P. dynamos parallel for several nights, resistances being used to bring up the total load to 200 amperes and 2,000 volts. It is expected that the consumption will grow very fast in the autumn, and therefore a third 500 H.P. set has been ordered from the Helios Works and Gebrüder Sulzer, of Winterthur. Mr. Ferranti stated that he had not the least difficulty in running his machines parallel, even without any load, a fact which is not, perhaps, generally known, the reason he gave being that the machine was practically without any self-induction. Be this as it may, I know as a fact that the large alternators at Cologne and at Vienna run parallel to perfect satisfaction, and may be switched in or out without any fluctuation of the voltmeter, although these iron-cored Zipernowsky machines certainly have a good deal of self-induction. Mr. Ferranti admired the automatic regulator, the instantaneous action of which he could observe; and he was astonished to see the Bláthy 100-ampere meter start with one 16 c.p. lamp on. At present two 80-kilowatt dynamos are

* *Journal für Gasbeleuchtung, Electrician* Vol. XXV., p. 404.

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at work. There is one interesting feature when the two large alternators are coupled in parallel. Looking at the magnet-wheel of one of them, you see the other magnet-wheel apparently standing still for some while, and then trying to move a little in one direction or the other, being kept in step by the controlling force that the two parallel machines exert upon one another. It is even possible to use this optical demonstration instead of the ordinary synchronisers. As soon as the two field-magnets seem to stand absolutely still, if you look at them in the direction of the shaft, the machines are in step, and the synchronisers will burn brightly, and the moment has come for coupling the machines in parallel.

The Frankfort civic authorities are becoming alive to the danger there is that many large electric light consumers will be supplied from block central stations. The site for the municipal central lighting station has been purchased, and the price paid shows that the situation is far from central; and whether the system ultimately adopted be the alternate or the continuous current, it will be a hard job to earn anything on the money that this station has swallowed already. Trials have been made costing thousands of pounds, experts have been consulted for year after year, schemes have been worked out by the dozen, and the Exhibition must also be counted as a costly item; it is certain that it would not have had such a success had the central-station contract been settled *before* its opening.

At the Electrotechnischer Verein of Berlin Herr Friedr. Ross lately read a Paper upon the cost and profits of central stations, in which he made some valuable proposals. The first of his proposals was similar to that of Mr. Crompton, namely, a regular exchange of data and opinions by central-station managers all over the world. At Düsseldorff Herr Ross stated that there had been an outlay of 840,000 marks on the plant for 13,000 to 14,000 lamps, or 60 to 64 marks per lamp. At Cologne, with 1,114,000 marks for 20,000 lamps, the figure is 57 marks. At Berlin it may be taken at 40 marks per lamp. These figures do not include the cost of the real estate, which was 5,700,000 marks at Berlin, and 600,000 marks in the case of the small station at Hamburg. For large stations on the outskirts of a town the cost of the generating plant may be taken at 50 marks per lamp, or about 1 mark per watt. The mains have cost 1,270,000 at Düsseldorff and 620,000 marks at Cologne, or 63·5 marks and 31 marks respectively, for each of the 20,000 lamps for which both these systems are calculated. These numbers include the house connections, and in the last case also the transformers. At Berlin the cost of the mains per lamp connected may be set down at quite 100 marks. According to Herr Ross the real cost of working for sufficiently large stations may be taken as 0·4 pfennig for administration, 0·25 pfennig for repairs and renewals, and 0·85 pfennig for current production, in all 1·5 pfennig for a unit of 50 watt hours (3d. per B.T.U.). Taking the high number of 1,000 burning hours per annum, Herr Ross pointed out that the total outlay is—

1. The real working cost for 50 watt-hours.....	1·5	pfennig
2. Interest and depreciation 10 per cent. of 50 marks for 1,000 hours.....	0·5	,,
3. Profit on the 50 watt-hour unit	0·5	,,
	2·5	pfennigs

leaving, at the assumed selling price of 3·5 pfennigs for the 50 watt-hour unit, an outlay of 1 pfennig for the mains, which, capitalised for 1,000 hours at 10 per cent., gives 100 marks, a figure which has so far only been reached by a few stations. It must be kept in mind that these 100 marks per 50-watt lamp have to include the house connections, and that a street length of 3·2 metres must be reckoned per 50-watt lamp connected, thus leaving a sum of less than 25 marks per running metre of useful street front. Herr Ross then proceeded to express a pessimistic view as to the future of electric motors as a means of increasing the earnings of a central station. He calculates that one H.P.H. may be sold at 8 pfennigs by the gas companies, and that an E.H.P.H. would cost 31 pfennigs. This latter figure seems somewhat extravagant, as the Berlin central stations sell the H.P.H. at 15 pfennigs.

The alternate-current central station belonging to the International Electricitäts Gesellschaft at Vienna has increased rapidly. It started in November, 1890, with a normal load of 524 kilowatts; on January 1, 1892, the load was 1,378 kilowatts. Each lamp connected is burnt on an average 780 hours per annum. The alternators were made by Ganz and Co., of Budapest, the engines by the Brünner Fabrik, and the boilers are, I believe, of the Babcock-Wilcox type. As at Cologne, the alternators are run in parallel. The cables were manufactured at Jacottet by the Austrian house of Messrs. Berthoud and Borel, of Cortaillod, who furnished the cables for Cologne.

At Cologne some very interesting experiments have been made lately with the telephone cable, which is laid next to the electric light cables. There was not the least "humming" to be heard, even when the two telephone wires were connected to one battery pole, the other pole being connected to earth.

It may be interesting to state that the German Elmore Company have erected large works at Schladem, near Cologne.

CORRESPONDENCE.

"ON THE RETARDATION DUE TO IRON PIPES."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sorry to have to admit that I quite forgot Prof. Hughes' work in this direction, but his letter is so interesting that perhaps you will insert it, together with an extract from his paper.—Yours, &c., W. H. PREECE.

G.P.O., May 2, 1892.

"DEAR PREECE: I notice in *The Electrician* of April 29th your Paper on "The Retardation Due to Iron Pipes," and as I take an interest in this subject I should like to point out to you a few of the experiments I have already made on this subject, which certainly agrees with the views you have expressed.

In 1866 I read a Paper to the Institution of Electrical Engineers on "The Self-Induction of Electric Currents," which was published in their journal, No. 60. You will find there, page 95, that I showed the remarkable diminution of the self-induction of an iron wire by coating its exterior with a copper sheath. The compound wire tried was one given me by yourself, and I believe was the invention of Prof. Moses G. Farmer, of the United States.

Again, a still more remarkable increase of self-induction was shown by a copper internal wire coated externally with iron. This was also given to me by yourself.

The greatest increase of all, however, was shown when an insulated copper wire was placed in an external iron tube, the effects of which was fully equal to those you mention as being later observed in actual practice by Gen. Webber. Page 98 gives a table of comparative results, with and without an iron tube.

Again, in a Paper read before the Royal Society, May 24th, 1866, which I enclose, you will find under the title of "Influence of a Magnetic Sheath," page 463 to 466, a full research into this most interesting point. This shows that an iron tube surrounding an insulated copper wire conveying an interrupted or alternating current has the effect of increasing the apparent resistance of the copper wire seven times its value in the steady period, by the self-induction, or really the production, of circular magnetism in the outer sheath of iron.

You will notice that these effects are due primarily to closed circular magnetic circuits, as can easily take place in a tube, but which cannot so well be formed in a submarine cable, as then the mere separation of the wires prevents a perfect closed system of circular magnetism, and the retardation or diminution of the current is a mere fraction of what it would have been if it had been enclosed in a solid iron tube.

These experiments were made on short lengths, and the results I then obtained have all been since verified in practice, except my results with the iron tubes, so I naturally feel interested in your letter, which again proves that my results were correct, although at the time my method and results were severely criticised by Prof. Weber of Zurich. As I could not then prove the truth of my results by actual practice on long lines, I shall be very glad if you can continue your experiments on this subject and publish the results.—Sincerely yours, D. E. HUGHES.

W. H. Preece, Esq., F.R.S.
40, Langham-street, W.
May 2, 1892."

[Prof. Hughes' Paper was read before the Royal Society on May 27, 1886, and was reprinted in full in *The Electrician*, Vol. XVII., page 71, *et seq.* The passage referring to the influence of "Circular Magnetism," will be found on page 95, and to a "Magnetic Sheath" on page 118.—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the very interesting particulars in your last week's issue of the effect of placing cables carrying alternating currents in iron pipes (each cable in a separate pipe), most electric light engineers who have had to deal with alternating currents were, no doubt, aware that there would

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be a choking effect, but I think that but few would have anticipated so large a fall of potential as was observed by General Webber in the case in question. The remedy indicated by Prof. Ewing, viz., drawing the two cables into one pipe, is, of course, universally practised. In view of the probable development of the alternate-current transformer sub-station system of distribution with a low-tension three-wire network, it would be interesting to know if there would be any similar losses if the *three* wires were in one pipe or iron conduit. May I venture to ask Prof. Ewing if he will be good enough to give your readers some information on this point, and so add one more obligation to the many which we already owe him?—Yours, &c., H. W. W.

"THE KELVIN."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As you are doubtless already aware, the Board of Trade has added one more name to the terms commonly used in electric lighting. We have for some years been accustomed to speak of Board of Trade "units"; we must, in the future, speak only of Board of Trade "kelvins."

No doubt honour is due to Lord Kelvin, and it is an old saying that honour should be given to those to whom honour is due; but it is very doubtful whether the change will add to the reputation or popularity of the President of the Royal Society.

It has long been a question whether many of the terms used in electric lighting do not tend to confuse rather than to assist. The science is not easy, and it does not add to the facility for education that the terms used should have no relevance whatever to the meanings assigned to them.

In a recent case we had an inquiry from the learned judge—whose great ability is shown by the manner he mastered the difficulties of a difficult case—how the word "ampere" was spelt, and whether it was the same thing as a volt. It does not seem that the necessity for such an inquiry reflected well upon an industry the great claim for which is light, and it does not seem to be wise, therefore, that if changes must take place, they should be in the direction of greater complication.

Everyone can guess at the approximate meaning of a "unit," but even the most learned philosopher would be unable to make a guess at the meaning of "kelvin" unless he had read a Board of Trade Provisional Order.

In these days of democracy it has been the experience of those responsible for electric lighting central stations to find customers in the smallest houses and amongst the least educated people; but if the industry is to be carried on in the language of capitals and proper names it will soon become necessary for each supply company to engage a special staff of interpreters to explain the meaning of its measurements to proposed customers.

It is already becoming a fact that the establishment charges of a supply station are equal to the cost of generation; and if these charges are to be increased in this manner the small chance of profit to the investors will rapidly disappear.

Just imagine what would happen if—

A battery were called	"A Swinburne."
A transformer	"A Webber."
An earth return.....	"A Crompton."
A switch	"A Lane Fox."
A meter	"A Hopkinson."
A dynamo	"An Aron."
The three-wire system.....	"The Eustace Balfour."
A high-tension current.....	"A Kennedy," and
A low-tension current	"A Ferranti."

Surely such a nomenclature would create confusion, even in the minds of those who heretofore had been supposed to know most about electricity. And yet this is, it would appear, what things are coming to.—Yours, &c., M.

[Owing to great pressure on our space we have been compelled to hold over a portion of our Correspondence until next week.—ED. *E.*]

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Corporation of Hull are prepared to receive tenders for supplying and erecting wrought-iron steam, water, drain, and blow-off pipes, cast-iron exhaust pipes and tank, pumps, injectors, &c. Drawings and specifications may be inspected at the borough electrical engineer's office, Central Police Station, Hull; and sealed tenders, endorsed "Tender for Steam Pipes, &c.," are to be addressed to the Chairman of the Electric Light Committee, and delivered at the town clerk's office, Town Hall, Hull, not later than Wednesday, the 18th inst. Further particulars appear in our advertisement columns.

——— It will be seen by our advertisement columns that the Corporation of the City of Liverpool invite tenders for the execution of certain electrical work, consisting of wires and instruments for about 95 miles of telephone communication, with alarm bells and other electrical appliances required between Liverpool and Lake Vyrnwy, and between Liverpool and Rivington. Tenders must be addressed "The Town Clerk, Municipal Buildings, Liverpool," and delivered before 12 noon on Tuesday, June 7th.

——— The Corporation of Blackpool are prepared to receive tenders for the right of user for a period of seven years (with provision as to conditional renewal) of certain tramways constructed and authorised under the Blackpool Corporation Tramways Order, 1884. Tenders to be delivered to Mr. T. Loftos, town clerk, before 12 noon on Saturday, June 25th. Further particulars appear in our advertisement columns.

——— The Directors of the Yorkshire House-to-House Electricity Company (Limited) invite tenders for the supply and erection of the necessary machinery, &c., for a central supply station, and for providing and laying underground mains. Further particulars will be found in our advertisement columns. Tenders must be in by 11 a.m. on Thursday, the 26th inst.

——— The Corporation of Dublin are prepared to receive tenders for the supply of wires, fittings, and sundries, and the erection of the same for the electric lighting of some of the civic buildings.

TENDERS ACCEPTED.—The Metropolitan Asylums Board have accepted the offer of the General Post Office to provide and maintain telephonic communication between the western ambulance station and the administrative block of the adjoining hospital, at a rental of £5. 15s. per annum.

TENDERS RECEIVED.—At a meeting of the Bideford Town Council on Wednesday it was reported that only one tender had been received for lighting the town by electricity, which was from Messrs. Tardrew and Son, who estimated the cost of laying down dynamos, engines, wires (underground), cost of lamps, and of everything connected with providing plants and starting works at the Manor Wharf, at £4,680; and that the annual cost of supplying all the public lights of the town—and 505 other lomps if necessary—would be £620 per annum. The offer was referred to a committee to report upon.

MR. JULIUS SAX.—The Markets Committee of the City Corporation have, it is stated, granted a concession for 21 years to Mr. Julius Sax for the electric lighting at the Central Market, West Smithfield, London, E.C., Mr. Sax having undertaken the public lighting of the market free of charge.

DISSOLUTION OF PARTNERSHIP.—Messrs. Stanley and Dawkins, electricians, 80, Buckingham-street, Birmingham. Debts paid by W. A. Dawkins, who continues the business.

BANKRUPTCY.—Tuesday night's *Gazette* contains a notice of the bankruptcy of J. Slater Lewis, described as an electrical appliance manufacturer's manager.

DOMESTIC ELECTRICITY.—The display of domestic electrical appliances on view at the Crystal Palace Exhibition has, we learn, become quite a feature, and is much appreciated by the public. New apparatus has recently been added, and the lecture given twice each day by Mr. H. J. Dowsing is always largely attended. We learn that the success of this show has led to an order being given to Messrs. Crompton and Co. and the General Electric Company to supply a similar exhibit for the forthcoming International Horticultural Exhibition at Earl's Court, London. This is well worthy of still further extension, and we have no doubt that similar shows will be on view at future exhibitions throughout the country.

ELECTRIC LAUNCH AT THE CRYSTAL PALACE EXHIBITION.—Messrs. Woodhouse and Rawson have lately added to their stand at the Crystal Palace an electric launch. The "Lily" is 28ft. long, has a beam of 5ft. 6in., a depth of 2ft. 10in., and a drught of 2ft. The boat is built of mahogany, the sides being carvel with American elm keel and timbers, and has an oak stem, stern post and dead wood. The electrical equipment consists of a 2-H.P. "W. and R." motor, supplied wiih current from 30 "Epstein" cells. The weight of the launch complete is 25 cwt. She can accommodate from 12 to 15 passengers, and with one

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charging (which occupies about four hours) will run seven miles an hour for five hours.

COUNTRY HOUSE LIGHTING.—"Lawnhurst," which is being built by Mr. Henry Simon at Didsbury, is to be lit electrically by Messrs. Drake and Gorham. Two Crossley gas engines will supply the power, and the current will also be used for driving a workshop, blowing an organ, and other purposes.

MESSRS. SIEMENS BROS. AND CO'S. WORKS.—The *Manufacturers', Engineering, and Export Journal* for April contains a very full and well illustrated description of the above firm's various works.

ISLE OF MAN INTERNATIONAL EXHIBITION.—An illustrated prospectus relating to this Exhibition has been issued this week, accompanied by a form of application for space, at the back of which are the instructions and regulations of the Exhibition. All further information can be obtained of Mr. Henry W. Pearson, General Manager, at the Exhibition Offices, Belle Vue, Douglas, Isle of Man, or of Mr. George North, of 90, Queen-street, Cheapside, E.C., representative in London for the Exhibition Commissioners.

"TELEPHONES: THEIR CONNECTIONS AND CIRCUITS."—Messrs. G. and M. Binswanger, of the General Electric Company, have just published a handy treatise on the above subject. The little book is fully illustrated, and the instructions given to those wishing to instal the telephone are full enough to enable anyone with an elementary knowledge of electrical apparatus to effect their object without outside assistance. Probably, with the exception of electric bells, the installation of the telephone most appeals to the ingenuity of the novice, and he should certainly find this *bro hure* of considerable use to him.

NATIONAL TELEPHONE COMPANY (LIMITED).—This Company notify their subscribers that on and after May 1st inst. a charge of 6d. will be made for the use of the trunk line between London and Brighton for each conversation of three minutes' duration, the charge to non-subscribers being double that rate. There is a six minutes' limit, and subscribers wishing to use the line have to enter into an agreement with the Company on a form which can be obtained on application.

ASSOCIATION FOR THE PROTECTION OF TELEPHONE SUBSCRIBERS.—A circular has been issued, notifying that this Association has been registered under the Companies' Acts, which information was given in our issue of April 18th last. It is stated that the Committee of the Association have satisfied themselves that the double-wire system adopted by the New Telephone Company is, in all respects, a great improvement upon the existing system. There is nothing in the circular to show how this conclusion has been arrived at, except that the National Telephone Company has not taken the Association seriously, and the New Telephone Company appears to have done so; in fact, it is evident that the Association has gone over, body and soul, to the New Company. Under the circumstances, telephone subscribers are, we fear, not likely to reap much benefit from the Association. At a small meeting held yesterday at the Cannon-street Hotel, it was unanimously decided to confirm an agreement with the New Telephone Company, conferring certain privileges with regard to the use of the Company's telephones upon members of the Association.

POSTAL AND TELEGRAPHIC REFORMS.—A draft letter is being prepared for signature to the Postmaster-General, with the object of inducing him to take into consideration a number of proposed reforms in his department. The petitioners represent an influential body of newspaper proprietors and managers, but the objects of the petition have a wider significance. These are (for the present) 17 in number, and are as follows:—(1) That all surplus of revenue over expenditure in the Post and Telegraph Department shall be at the sole disposal of the Postmaster-General, for the purpose of instituting Postal and Telegraphic reforms, and to be subject to no control by the Treasury Department, until such reforms have been effected, when the surplus is to be handed over to the Chancellor of the Exchequer. (2) That the postage on periodicals shall be uniformly one-halfpenny per copy. (3) Relates to the proportion of advertisements to news matter. (4) The hour of collection to be stamped on all postal packets. (5) The public to be allowed to transmit ordinary cards (official size) as postcards by the use of adhesive stamps. (6) Postcards to be sold at the face value. (7) The public to be supplied with double postcards, to be used for message and reply; these to be termed "Query" postcards. (8) A cash-on-delivery post to be established in this country, so that a Parcel Post official shall collect the money due upon the parcels he delivers. (9) Type-written and similar circulars to be transmissible at the book-post rate. (10) The establishment of an agricultural parcel post at an average charge of 1d. per lb. (11) The reduction in the case of inland parcels to a minimum of 3lb. for 3d, and a penny for every additional pound. (12) The issue of small money orders payable either at home or in our colonies. (13) The collection by the postal authorities of not more than the deficiency on any insufficiently stamped letter; this is in place of double the deficiency now collected. (14) All compound names of places in telegrams to be charged as one word. (15) The abolition of charges for porterage on telegrams, or at least a reduction of the charge to a sum proportionate to the wages of the messenger, which in the petition is put down at a penny per mile. In addition, the number of telegraph stations in country districts to be largely increased. (16) The adoption of the Indian system of sending cash with a telegraphic money order to the residence of the addressee. (17) Telegrams to be forwarded to France, Belgium, Germany, Canada, and the United States at 1d. per word; to India for 6d., and to Australia for 1s. per word. The existing cable systems to be purchased by the Government at a fair valuation. It will be seen that this imposing list of reforms loses nothing by being sponsored by newspaper proprietors.

COMPANIES' MEETINGS & REPORTS.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The thirty-seventh ordinary general meeting of this Company was held on Wednesday, at Winchester House, Old Broad-street; Sir John Pender, K.C.M.G., presiding.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the last meeting, which were approved by the present meeting, and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I shall, as usual, go over the accounts in detail, and if any shareholder should have any questions to put to me afterwards, I shall be only too pleased to answer him. The gross receipts for the half-year under review have amounted to £245,658, against £279,095 for the corresponding period of 1890, showing a decrease of £35,437, of which nearly £12,000 is due to fluctuations in exchange, £14,000 to the reduced rates to Australia, to which I shall presently refer in greater detail, and the balance to the commercial depression which has prevailed in the Far East for some time past. The working expenses have been practically the same as during the corresponding half-year of 1890. Comparing the figures for the whole year the results are as follows:—The gross receipts for 1891 were £508,536, against £533,951 in 1890, or a decrease of £25,415. The working expenses for 1891 were £145,790, against £150,760 in 1890, or a decrease of £4,970. The net revenue for 1891 was £289,522, against £303,482, or a net decrease for the year of £13,960. The usual interim dividends have been distributed during the past year, making the dividend proposed to be paid to-morrow a total dividend of 5 per cent. for the year. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the past year. The balance of £111,987 has been carried to the general reserve fund, which now stands at £428,842, made up as follows:—Amount of fund at end of 1890, £495,239; interest on investments during year, £15,129; profit on sale of investments, £1,424; and balance from revenue, £111,987, making a total of £623,779, less £144,135 charged against reserve during the year for balance of cost of Madras-Penang (Duplicate) Cable; also £35,878, for balance of cost of partial renewal of Hong Kong-Tonquin and Madras-Penang (Original) Cables; and £14,924 for cost of Penang-Sumatra cable, leaving the fund, as already stated, at £428,842. Since the amalgamation in 1873 we have spent out of revenue and reserve in cable renewals and duplications, £1,153,736. If that sum had not been spent I doubt if you would be receiving the dividend we are about to pay, and I am quite sure that our Company would not occupy the very proud position that it does to-day, for you have got your cables duplicated and some sections triplicated, you have not had your capital increased, and your dividend has been maintained. A further drawing of 337 of the Company's Five per Cent. Australian Subsidy Debentures took place on the 4th ultimo for payment at par on July 1st next, when the Debenture Debt, which originally stood at £640,000, will be reduced to £320,000. With regard to the reduced rates to Australia, which is a very important question, I may mention that since the report was issued to the shareholders we have completed another month's working under the guarantee arrangement made with certain of the Australasian Governments for testing the effect of a 4s. rate to Australia, and we are consequently in a position to give the figures for the full year of experiment. The number of words transmitted during the year has increased 50 per cent. over the corresponding period of 1890-1891, and 61½ per cent. over that of 1889, the year adopted as the basis of the "guarantee," while the receipts have diminished to the extent of £55,040. As you are aware, one half of this loss, or £27,520, is borne by the guaranteeing colonies, divided as follows:—Victoria £11,189, New South Wales £11,136, South Australia £3,265, Tasmania £1,498, Western Australia £432; and the other half by the associated companies and the Indo-European Department of Her Majesty's Indian Government, the Extension Company's proportion being £17,770, the Eastern Company's proportion £7,862, the Indo-European Company's proportion £1,167, and the Indo Departments £721. As your Directors never expected that the entire loss would be recouped during the first year, they are not disappointed with this result, and have agreed to the experiment being continued for at least another year. In giving my own opinion upon this matter, it strikes me that the increase of traffic to which I have just referred is a very remarkable one indeed, and I have no hesitation in saying that we may look upon it in the future as permanent. At the same time, while I make that statement on this side of the table, we have to consult the Australian Colonies; but the payment which they have to make is so insignificant, compared with the

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enormous advantages they are deriving, that I cannot for a moment suppose that they will hesitate to continue the reduced rates. The Company's repairing steamers have as usual been busily employed during the past half-year; but, owing to most of the cables being duplicated, the traffic has not been materially affected except with Manila, which, unfortunately, was cut off from telegraphic communication with the rest of the world for several weeks. The interruption was caused through the breaking of the cable between Hong Kong and Cape Bolinao at each end of the line during a severe typhoon. Negotiations are, however, proceeding with the Spanish Government for the duplication of the cable, and it is to be hoped that a satisfactory arrangement will soon be brought about. All the various sections of the Company's system are now in good working order. In accordance with the arrangement concluded with the Netherlands Government, and referred to in the last report, the Company's system has been extended during the half-year under review from Penang to Sumatra, the necessary cable having been taken from stock at Singapore, and the cost of the operation (£14,924) charged against the reserve fund. An arrangement has also been entered into for the manufacture and laying, on account of the Netherlands-Indian Government, of a cable to connect Acheen with the Company's new line at Sumatra; and the Telegraph Construction and Maintenance Company's s.s. "Seine" will this week leave the Thames with the requisite cable on board to carry out the work. A considerable business is carrried on between Sumatra and Penang, and it is therefore anticipated that the improved telegraphic facilities thus provided will in time prove important feeders to the Company's system. Now, gentlemen, the next matter I am going to draw your attention to is the staff pension fund. The shareholders having at the last meeting approved the principle of establishing a staff pension fund, your Directors have had a scheme prepared by experienced actuaries, who advise that an annual contribution by the Company of 2½ per cent. on the salaries, and a similar contribution by the staff, would, if invested at 4 per cent. compound interest, provide sufficient funds to make adequate retiring allowances for the younger members of the staff on their attaining 60 years of age, but as many of the older *employés* have already seen considerable service, and their retirement in some cases cannot be far distant, 2½ per cent. would be insufficient to place them on an equally favourable footing. With a view, therefore, to supplementing their allowances from the pension fund, the actuaries advise that, in addition to the 2½ per cent. just referred to, the Company should continue their present contribution to the endowment assurance fund in full until all the existing policies are paid off, and allow the savings effected by the premiums ceasing to be payable to the Assurance Company as the policies mature from time to time to be applied exclusively for the benefit of the older servants. The wish that the older servants should not be placed on a less favourable footing than the younger members of the staff was, I think, strongly expressed at the last meeting. The actuaries further recommend that the Company should guarantee 4 per cent. interest on the accumulations of the fund. Provision is also made in the actuarial calculations for dealing with cases of death or breaking down in health before reaching the retiring age, and for other contingencies. This is a fair outline of the actuaries' scheme; but as the various details are still under consideration by the Board, it is proposed to ask you to-day to approve a resolution in general terms empowering your Directors to bring the scheme into operation when the details are finally settled. Now, before leaving this subject, and before placing the resolution before you, I think it is right to tell you that no question has received more serious consideration than this, and I do not know that the shareholders can do better for the Company's interests than to carry out this scheme. It is important to secure an efficient staff, and it is important to see that their future is one of brightness, and not of darkness; and, on the whole, looking at the salaries they receive and the amount which they will receive from the pension fund, I think I may venture to say that very few of them would feel any inconvenience from being placed on the retired list, when they reach the retiring age. I am quite sure that the expense to the Company will be comparatively small. Years hence this question may be discussed again, and by intelligent people, probably in this room; and I desire, above all things, in bringing this matter now before you, that instead of being blamed hereafter for doing anything unjust either to one party or the other, the Board should be complimented upon the great care which they exercised, not only in the shareholders' interest, but also in the interest of the staff. This is a matter which cannot be finished in a day. We are giving every spare hour that we can to it. The actuaries are also giving it every attention, and every one in the concern, more or less interested, has had an opportunity of expressing an opinion on the subject. I, therefore, believe that we are going into this matter with thorough unanimity, and holding the opinion that it is for the Company's interests generally—the Directors bring it before you in the firm belief that it will meet with your hearty support. The resolution I have first to propose is as follows:—

"*That the report and accounts of the Directors now submitted be received and adopted; and that a dividend be now declared of 2s. 6d. per share, together with a bonus of 4s. per share, both free of income tax, payable on the 5th instant, making, with the previous distributions, a total payment of 7 per cent for the year 1891.*"

The Most Hon. the MARQUIS of TWEEDDALE: I beg to second the resolution.

Mr. JOHN NEWTON: I do not think that the resolution should be carried without an expression of opinion on the part of the shareholders in regard to the important step which you have taken relative to the staff.

The CHAIRMAN: I think that before that matter is discussed the resolution bearing upon it ought to be before the meeting.

Mr. NEWTON: I desire, then, to make a few remarks on another part of your speech. You have told us that since the amalgamation we have spent out of revenue and reserve in cable renewals and duplications £1,153,000; but in addition to that you have the reserve fund, which you stated amounted to nearly £500,000 more.

The CHAIRMAN: That is so.

Mr. NEWTON: That shows how much stronger the position of the Company is now than it was 20 years ago. All this amount has been added to our property, and at the same time we have paid a dividend averaging, I think, between 6 per cent. and 7 per cent. from the very commencement of the Company. That is a very satisfactory state of things, especially to those who were early shareholders, and I may state that I have been on the books of the Company for 18 years. Indirectly, I have also been connected with it through my interest in other companies. I desire to express my satisfaction at the position which the Company has now attained, inasmuch as we now feel that we have a property ranking with the highest class of securities in the Kingdom. I have before said that telegraph property now ranks with railway property. It can be as easily repaired; and it must be a gratification to everyone who has invested in telegraph property in the last 18 years to find that it has reached a point when it now yields to an investor only 4½ per cent. Of course, we have to take into consideration the reduction of interest generally upon joint-stock enterprise; but when we remember the enormous sums which have been lost in other undertakings in the same time, we have a great deal to be thankful for to the Directors for what they have done for us in so vastly strengthening the position of the Company.

The CHAIRMAN then put the resolution to the meeting in the usual way, and, having declared it carried unanimously, said the next resolution is:—

"*That John Denison Pender, Esq., who now retires by rotation, be and is hereby re-elected a Director of this Company.*"

Mr. FRANCIS A. BEVAN: I have great pleasure in seconding the resolution. Perhaps the Chairman could scarcely say anything about his own son, but I should like to inform the shareholders that I am sure they derive great benefit from having the son of the Chairman taking an active part in this Company. He is, I can assure you, a most efficient Director, and I have great pleasure in seconding the resolution for his re-election.

The motion was carried unanimously.

Mr. J. D. PENDER: I beg to thank you, gentlemen, for my re-election.

The CHAIRMAN: I have now to propose:—

"*That the Most Honourable the Marquis of Tweeddale, who now retires by rotation, be and is hereby re-elected a Director of this Company.*"

Mr. CHARLES W. EARLE: I beg to second the motion.

The resolution was carried unanimously.

The MARQUIS OF TWEEDDALE: I beg to thank you, gentlemen, for your renewed confidence.

Mr. FIELD: I beg to move:—

"*That Mr. Henry Dever and Messrs. Welton Jones and Co., be and are hereby re-elected auditors for the ensuing year at a remuneration of £100 each.*"

Mr. NEWTON: I second the resolution.

The motion was carried unanimously.

The CHAIRMAN: The next resolution which I have to propose is as follows:—

"*Resolved.—That this meeting approves of the establishment of a Staff Pension Fund and authorises the Directors to carry out the same upon such terms and conditions as they may think expedient.*"

I am asking you to give the Directors your full confidence in regard to this scheme. You have expressed yourselves warmly on previous occasions in regard to this subject; and I have been clear, I hope, and distinct in telling you that while we wish to benefit our staff, we shall be benefiting still more the interests of the Company. Even at a time like the present there is a demand for good telegraph clerks. We have trained not only good, but generally the best telegraph clerks in existence. We have an institution for the purpose, but we think it is very hard sometimes to find that after several years' training, these young men are encouraged to go elsewhere by higher salaries. We cannot object to that, for they have to make the best way they can in the world, but we think that if we make it their interest to stay with us we shall derive not only all the advantages of their early training and the expense we have incurred in that matter, but that we shall have people about us that we know something of; and it is our desire to make, if possible, the staff of this Company—who are now spread very much all over the world—feel that the best place for them is with the old Company. That is what we desire to do. The resolution will be seconded by Sir James Anderson, who knows all the details as well as any man living, and who takes a warm and deep interest in the staff; and you may rest assured that altogether the matter is in good hands.

Sir JAMES ANDERSON: I beg leave to second the resolution, and I have great pleasure in doing so.

Mr. JOHN NEWTON: I should now like to finish what I was going to say before. At the last meeting I suggested that the older members of the staff should be considered in this scheme, and I am glad that you have done so. In early years I was not altogether a *persona grata* with the Directors of this Company, and occasionally I had some contests with them on certain questions. At the same time I came into contact with several of the officials, and I was surprised at the great courtesy with which I was received by them, although I was in opposition to the Directors. When shareholders receive such treatment as this I think that they should express their opinion when a matter of this kind comes before them, that the older members of the staff should not be neglected. The younger members can look after themselves, because the future generation of our servants will be greatly benefited. The staff having an interest in this fund will see that it will be to their benefit that the Company should be prosperous, as if not there will be some peril to their pensions. You will

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have an economical staff, and that will make up for what you may be sacrificing at the present moment. It is not, however, in my opinion a sacrifice that we are asked to make, but is really a further strengthening of the property, and making it a solid one for investors, because the property, scattered all over the world as it is, will be protected by a body of faithful servants, whose interest it is that the Company should prosper. As the junior members of the staff will be so greatly benefited in future years by what is now proposed to be done for them, I do think that the interests of the older members should not be overlooked, but that they should have the full benefit of any allowance we may make if they should have to retire next year. The property is so greatly improved that you need not fear that you will have the hearty approval of the shareholders of the Company in giving a proper measure of justice to the old servants of the Company.

The CHAIRMAN then put the resolution, which was carried unanimously. Continuing, he said: I think that I have pretty well exhausted all the subjects which had to be brought before you on this occasion. I have put down a few notes here, but I think that what I have said and read will convince you that a very satisfactory state of things exists in connection with our Company. I can only say that, good as our position is to-day, I see no reason why it should not continue so in the future.

Mr. BLUNDELL: Before the meeting separates I have much pleasure in proposing a resolution, which I am quite sure will be carried *nem. con.*, like the others—that is, that the best thanks of the meeting be given to the Directors for their services during the past half-year, and to the Chairman for his conduct in the chair to-day. I can only congratulate them upon having brought their labours to so satisfactory a conclusion, and I trust that they may be long spared to rule over the Company in the same efficient manner as they have done in the past.

Mr. W. GRIFFITH: I have very much pleasure in seconding the resolution.

The motion was carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I have the greatest possible pleasure in thanking you. I may tell you that I have come here to-day with the strongest possible desire not to break my record. I have attended every public meeting of this Company since its inception. For the last fourteen days I have been confined to my room by bronchitis. I have not escaped the penalties which men in all stages of life have been subject to, but I thought it was my duty to make an effort to come among you to day. This is my first day out, and I only hope that it is the beginning of my complete restoration to health.

The proceedings then terminated.

Brazilian Submarine Telegraph Company (Limited).

The thirty-seventh ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Wednesday, under the presidency of Sir James Anderson.

The SECRETARY (Mr. Richard Collett) read the notice calling the meeting, and the minutes of the previous general meeting, which were confirmed by the present meeting and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN then said: Gentlemen, as you have had the report and accounts before you for some time, I presume I need not do more than, as usual, call your attention to some of the salient points. There is a decrease of revenue of £31,819 as compared with the previous half-year; but I must remind you that the accounts of several of the previous half-years have included abnormally large receipts arising from exceptional causes in South America, with which you are well acquainted. The existence of a more settled state of affairs has resulted in a falling-off of the exceptional traffic, and this accounts partly for the above large decrease. It is, however, chiefly due to the abnormally low rates of exchange which existed in Brazil during the half-year under review, and which, I am sorry to say, still continue. We can only hope that by-and-by the value of the Brazilian currency will improve. There has been an increase on the expenditure side of £7,037; of this, £3,422 is an increase in cost of repairs of cables, which, last half-year, was £13,450, as compared with £10,028 in the half-year before that. We must, of course, be at all times prepared for expenditure upon repairs. Then there has been part of the cost of duplexing our newest cable, amounting to £3,000, and £587, the cost of training the necessary operators to work duplex, and further strengthen our staff for a continuous day and night service, so as to create a speed and accuracy which cannot be excelled, and I hope will not be easily equalled when our joint system is duplicated and duplexed, and certainly not with single cables, which is all our rivals have yet projected. After paying two interim quarterly dividends at the rate of 6 per cent. per annum, we carry forward the sum of £19,893, and I shall be disappointed if you do not as usual receive a bonus at the end of the financial year payable in October. I am glad to say the current half-year's working is not unsatisfactory. There is one other matter I should like to refer to. You are aware that the cables of the Western and Brazilian Company are partly duplicated, and that it required the laying of a second cable between Santos and Chuy, to provide a complete duplicate system between Great Britain and Buenos Ayres. The want of this complete duplication prevented the service with the River Plate being entirely satisfactory to your Directors as a strong competing line, and as it is at Buenos Ayres that the Central and South American Company can best compete for traffic, we have arranged with the Western and Brazilian Company that they shall lay the necessary cable. The cable is now being laid, and will, I believe, be landed to-day, and I am sure this cable will lead to results greatly to our mutual advantage and success in dealing with our competitors. The cost incurred by the Western Company has been very large, and as the Brazilian Company's fair contribution your Directors have agreed to pay that Company a fixed sum of £6,000 per annum instead of making any alteration in the percentages of the joint purse. In addition to the advantage of the extra cable the Western Company give us the right to use their repairing ship for repairs of our cables off the coast of Brazil at a moderate charge per day. In certain cases this arrangement will save the expense of fitting out a steamer in Europe, with the long journey to Brazil and back. I think I need not further dilate upon the revenue or expenditure, but go on to what I have to say in regard to the present and future aspect of our affairs, as this subject presses more upon my own mind, as I dare say it does upon yours. First, then, it is true our existing rival on the West Coast of America has forestalled us in securing the trans-Andine line between Buenos Ayres and Valparaiso, and has so arranged his tariffs as to shut us out for the present from any share in the Chilian and Peruvian traffic, but the companies interested in passing this traffic by the East Coast route, namely, the West Coast of America Company, the Western Brazilian, and this Company, are arranging for the construction of an independent trans-Andine line of improved character between the Atlantic and the Pacific, and we shall then see how far our rival—the Central and South American Company—can retain the ground it has taken. The Central American Company has commenced cutting rates. We had carried out a policy of gradual reduction as circumstances permitted, ranging from 33 to 50 per cent. of the old rates, according to locality, and we should no doubt have continued this policy had not these rival cable projects sprung up. We have not initiated a war of tariffs, nor have we yet gone so far in reductions as our West Coast rival, but we are prepared, whenever we see it to be in your interests, to accept the challenge. We shall certainly not remain at a higher tariff than our rivals when the time comes to accept the position, and in the meantime we are daily watching the course of traffic and safeguarding your money and interests with care and forethought. I may now refer to our second rival, the Antilles Cable. This company has not made any mark so far, and it is certainly not to their interest to reduce tariffs. I think they must be watching with some anxiety the development of the other rival lines. Of course we know what the French Antilles Company are trying to do, but unless they have Government subsidies it does not appear to us that they are in an enviable position. For all that, they must not be despised; they have spent a great deal of money, must expend a great deal more, and we may have to count with their opposition by-and-by. And now we have a third rival in the new Company—the South American Cable Company—just put before the public. That company proposes to unite Africa with Brazil by a cable between Senegal and Pernambuco, and so provide another route to Europe *via* Africa. I may remind you that Africa is already joined to Brazil, and the route to Europe is already in existence, as your cables at St. Vincent are in connection with that of the African Direct Telegraph Company, and in fact with the whole world. I am personally sorry we must oppose them, as we are individually on friendly terms, but the attack is from them, not from us. I do not think I should have felt it my duty to say anything against the company, whatever I might have thought, because contractors have a right to keep their machinery going if the public will find the money, or if they are rich enough to risk their own money. But the body and bones of the prospectus is that they hold this Company up as the one they intend to injure, and they base their estimates of revenue on a few exceptional years, when civil war by sea and land, revolution and financial crisis, caused reckless telegraphing and expenditure, which naturally inflated our receipts at a time when every other means of communication with the outer world than by our East Coast cables was stopped; and the prospectus complacently assumes that the new Company may reasonably expect to take from this Company £85,000 per annum of such extraordinary receipts, which have, however, since the advent of peace, already diminished, from one cause or another, by one-third. The tariffs are reduced, and certain to be still more reduced, while the loss on exchange on the charges collected in Brazil is equivalent to another very large reduction. Their prospectus says, in short, "This Brazilian Company has made a lot of money—will the public join us in a speculation to take as much as possible from them?" and they give data which I can assure them will prove disappointing. Well, the company is formed, the cable has been manufactured, the ship has sailed with it, and we shall just have to meet its opposition. On the last occasion of my addressing you it was said that I had made a pessimistic speech, and I dare say I did. One cannot see three rival companies attacking, or preparing to attack, our traffic, and speak to the proprietors as if it were an amusing trifle. At the same time, I was not, and said I was not, in any mood to despond, and neither I nor my colleagues are now in any fearful state of mind. Of course we are anxious, but so far as lies in our power, we will prevent our rivals taking from us that £85,000, or anything like it. We can look with great satisfaction upon our position. The entire system of the Brazilian Company is duplicated, and the newer cable is duplexed, giving practically the carrying capacity of three cables; the duplication of the cables of our partners, the Western and Brazilian Company, between our point of landing at Pernambuco and the River Plate, will be completed to-day or to-morrow, and the duplex working between London and the River Plate will then be arranged for. So far none of our rivals have projected more than a single cable each. Our traffic is being transmitted with great speed, which we are improving every month. We have duplicated our cables without increasing our capital, and we have a substantial reserve in available sovereigns for extensions or contingencies. We do not derive our revenue from South American traffic only, our receipts from the West Coast of Africa and the Cape Colonies being of considerable importance, but of this our rivals did not take any note, making their calculation as if all our revenue resulted from the traffic carried between Pernambuco and Europe; and, as I have already said, we shall soon have a direct line across the Andes to Chili, and all the way to Lima; in fact, a complete through communication from Peru and Chili to Great Britain and Europe. Gentlemen, we cannot make your position better; nothing that forethought or a judicious expenditure of your money could have done to strengthen

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the position of your Company has, in my opinion, been neglected, and with a continuance of this policy, we may look the future in the face with as much equanimity as the proprietors of any enterprise in the world of such a public nature can regard their present or future prospects. That is all I need say. I do not at all fear the result of this competition, come when it may. Having our lines duplicated and duplexed, we are in as strong a position as we can be, and we must wait and see the result. I have now to propose the following resolution :—

"That the report of the Directors, and the accounts to December 31, 1891, now submitted, be approved and adopted."

The Hon. W. ST. JOHN F. BRODRICK, M.P., seconded the motion.

A brief discussion followed, and, in answer to questions,

The CHAIRMAN said that the cost of the Transandine Line would be about £100,000—perhaps, £120,000, and it would be done by debentures, he thought, with a little capital, if necessary. This Company's share of the cost would be one-half, but he did not expect any loss on it, as the traffic on it would pay very well. They had gone very carefully into the matter. The new South American cable was expected by those interested in it to be open for traffic in July next. A project was being discussed in Lisbon as to giving the Company an extension of their monopoly for 10 years, and the Eastern Company a similar advantage, if they would connect Lisbon with the Azores. The French Company were, however, trying very hard to get the work, and therefore he did not know whether the Brazilian Submarine Company would get it. If they did, it would be a splendid monopoly for another 10 years, but it would cost them £50,000. The matter, however, was now under discussion. He then put the resolution, which was unanimously adopted.

Mr. ROUGHTON then proposed a vote of thanks to the Chairman and Directors.

Dr. H. ELLERY TREWHELLA seconded the motion, observing that the shareholders must have seen that they had a Board who were most vigilant in looking after their interests. As regarded their Chairman, he had never listened to more cautious remarks than those which had been made by Sir James Anderson on that occasion.

The CHAIRMAN, in acknowledging the vote, assured them that the past six months had been about as anxious a period as they had ever had. He was much obliged to them for the confidence which they had shown in the Directors.

The meeting then separated.

Submarine Cables Trust.

The twenty-first ordinary annual meeting of the certificate holders of the Submarine Cables Trust was held yesterday at the offices, Winchester House, Old Broad-street ; Sir John Pender, K.C.M.G., in the chair.

Mr. CAMBROOK (for the Secretary) read the notice calling the meeting and the minutes of the last meeting, which were approved by the present meeting, and signed by the Chairman.

The CHAIRMAN : Gentlemen, I will now give you a short statement of the position of the Company and of its revenue during the past year. The revenue for the past year amounted to £22,799, as against £23,666 in 1891, showing a decrease of £867. In the previous year the trustees made a small profit of £264 on a temporary investment of their current balances, and the income derived from our investment in Anglo-American stock is about £600 less than in 1891. The expenses for the year amounted to £1,186, as compared with £1,175, or a small increase of £11. The trustees beg to remind the certificate holders that the cost of administering the Trust is £813 under the amount provided by the trust deed. This is due in a great measure to the trustees not having filled up the vacancies as they occurred by the death of two of their colleagues. The trustees, however, think the time has now come when these vacancies should be filled, and they have considered it judicious to select two younger men, who nevertheless have considerable experience in submarine telegraph business, and knowledge of the securities in which the capital of the Trust is invested. The names of the two gentlemen are Mr. John Denison Pender and Mr. Kenneth Anderson, and a resolution will be put before you on the subject. We have paid during the year £7. 2s. 6d., but the balance brought forward from last year was equivalent to 15s. 7d. per cent. on the value of the outstanding certificates. Our revenue during the past year has been sufficient to meet two coupons of £3 each, and pay off about an additional 7s. of the overdue coupon. There remains still a balance of £1. 17s. 6d. in arrear, but should the dividend on our holding in Anglo-American Stock improve, and the income from our other investments be maintained, we trust this arrear will be gradually paid off. We hope to pay the balance of the coupon due April 15th on or about August 1st next. I think it right to state that a Trust of this kind requires the people concerned in its management to be more or less constantly in attendance, and therefore our proposed introduction of new blood into it is the right course to take. Some of us are getting into life, and our attendance may not be so regular as we could wish, but there must be always men in attendance to look after the work of the Trust. The suggestion which has been made to you as to the election of new trustees to supply the vacancies in that body was decided upon after considerable thought, and with the knowledge that the young men suggested for the positions know exactly the nature of the Trust, and they will also be in touch with the general public as to the value of the stocks we hold. For instance, Mr. Kenneth Anderson knows something of what is going on outside, while Mr. John Denison Pender knows perfectly well all that is going on inside. They know the nature of the Trust and of the investments, and I do not think we could have suggested two better men to fill the position of trustees. I now propose—

"That the report and accounts of the trustees to April 15, 1892, submitted to this meeting, be and the same are hereby received and adopted."

Sir JAMES ANDERSON : I second the resolution.

The motion was carried unanimously.

The CHAIRMAN : I will now propose the second resolution, which, I may state, has been specially prepared by our solicitors. It is as follows. Resolved—

"That John Denison Pender, of 51, Sloane-street, in the County of Middlesex, Esquire, and Kenneth Anderson, of 19, Ashburn-place, South Kensington, in the County of Middlesex, Esquire, be and are hereby appointed Trustees of the Indenture dated September 6, 1871, and made between Sir James Anderson, Sir Daniel Gooch, Bart., Lord William Hay, Viscount Monck, Captain Sherard Osborn, R.N., and John Pender, Esq., of the one part, and Philip Rose, Esq. (for and on behalf of all the holders for the time being of certificates thereinafter mentioned), of the other part, in the place of Sir Daniel Gooch, Bart., and Captain Sherard Osborn, R.N., respectively deceased."

The Most Hon. the MARQUIS OF TWEEDDALE : I will second that.

The resolution was carried unanimously.

Mr. E. CUNLIFFE OWEN then proposed the following resolution :—

"That Mr. John G. Griffiths and Mr. John Gane, both of whom now retire, be, and they are hereby re-elected auditors of the Trust for the current year, at a remuneration of £25 each."

Mr. BURMAN seconded the motion, which was carried unanimously.

The CHAIRMAN : I may mention that this Trust is of a peculiar nature. It is practically a tontine, which will wind itself up in a certain number of years, and therefore we require youthful men to see the end of it. Probably the young men you have appointed to-day will have to elect others hereafter to succeed them, but at all events it is a self winding up institution.

Mr. BURMAN then proposed a vote of thanks to the Chairman and Directors.

Mr. WILLIAM SHUTER seconded the motion, which was carried unanimously.

The CHAIRMAN : On behalf of my co-trustees and myself I am very much obliged to you. Trust Companies have been very much before the world for the last two or three years, but I think that ours will bear very close inspection indeed, and I feel sure that the more they are looked into the more they will be appreciated.

The proceedings then terminated.

Great Northern Telegraph Company.

The following is an abridged report of the proceedings at the general meeting held at Copenhagen, on the 30th ult. ; Mr. F. Zahle presiding.

The Chairman of the Company. Mr. C. F. TIETGEN, in rendering an account of the working of the Company during the year 1891, referred to the Company's cables, which, he said, had, on the whole, been working normally. In Europe the interruptions had actually been less frequent than in 1890, although the number of cables was at the present moment 12, or 16 if counted by sections, and the Company's cable steamer, "H. C. Örsted," had remained in port during nine months of the year. In the Far East the number of cables was now 9, or 13 if counted by sections, the system having been reduced by the sale to the Japanese Government of two small sections of the cable between Korea and Japan. The interruptions had been nearly as frequent as in 1890, the cable steamer "Store Nordiske" having been on active service for 187 days, of which, however, 66 days had been for account of others.

New Cable.—Although the new concession granted by the French Government was not ratified until June last, the laying of the duplicate cable between France and Denmark had been successfully carried out during the latter half of July. This cable, which had been manufactured by the Telegraph Construction and Maintenance Company (Limited), of London, was about 370 nautical miles long, and the core and armature had been chosen with the special view of securing an electrically and mechanically perfect cable of the most solid description. The effect of the establishment of this duplicate line had already shown itself in the greater amount of traffic and in the increased regularity and speed of transmission. The landplaces on the French and Danish coasts were the same as those of the old cable, but the new cable was laid in a track as far removed from the old one as practicable, in order to prevent simultaneous interruptions of both cables from the same cause.

New Premises in Copenhagen.—Although it would take a year or two before the Company's new premises in Copenhagen would be completed, the general offices, as well as the workshops of the Company, had already been established there since last autumn. The accommodation in the new house had given entire satisfaction in every respect, and the considerable extension of the workshops had rendered it possible to execute outside orders with greater promptitude than hitherto. Such orders had not been wanting during the past year, in fact they had contributed greatly towards reducing the amount charged to the working account under the item of "Instruments and Cells."

The Situation in China and Japan.—The anti-foreign riots, which had agitated the Chinese Empire during part of the year, had not interfered with the Company's business in any way. In one of the interior provinces, however, the animosity of the rioters against the telegraph had vented itself in the destruction of thousands of telegraph poles belonging to the Chinese Administration, and intended for the construction of an internal line. This occurrence was an additional proof of how indispensable submarine cables were in China, and how little foresight was displayed by those who agitated in favour of landlines to the detriment of the submarine connections. In Japan, the calamity brought about by the terrible earthquakes had awakened the sympathy of all, and the Board of Directors

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felt sure that, in assisting the relief committee in various ways, besides subscribing, on behalf of the Company, $2,000 for the benefit of the sufferers, they had only been acting in accordance with the wishes of the shareholders. The same remarks applied to a subscription of Rbls.5,000 to the fund raised for the relief of the distress in Russia; in both countries the Company had enjoyed protection and hospitality for a quarter of a century.

Traffic Receipts.—These had been most satisfactory during the first six months, in which they had even exceeded those of the corresponding period of the previous year. On 1st July, however, the tariff reductions fixed by the International Telegraph Conference at Paris, came into force, and these had caused a marked falling-off in the receipts for the rest of the year. When it was further taken into consideration that the embargo on the export of grain from Russia had very much affected the traffic, and that the rate of exchange on the remittances from the Far East had steadily declined, it would be easily understood that the advantage gained during the first half of the year had, to a great extent, been lost during the latter half. The effect of the depreciation in the value of silver currency had, in fact, been so great, that the "tael" which in August, 1890, was worth about 5s. 3d., was, at the present moment worth only about 3s. 10d., representing a loss of over 25 per cent. on all the receipts collected at the Company's stations in the Far East. Notwithstanding this, the total gross receipts were a little higher, while the expenses, thanks to the profits realised by the Company's workshops and cable steamers, were somewhat lower than in 1890.

Distribution of Profits, &c.—In the above circumstances the Board of Directors consider themselves justified in recommending that the total dividend be fixed at the same figure as last year, say, 17s. 2d. per £10 share, or about 8·60 per cent. In accordance with the intentions expressed in the last report, the Company had laid the very costly new cables without having drawn upon the investments of the reserve fund. On the other hand, however, the cash placed to the credit of that fund, and the amounts carried forward during the last two years, had been completely absorbed by those heavy expenses. In order to gradually counterbalance this, it had, therefore, become necessary to somewhat increase the usual addition to the reserve fund, and the amount carried forward to the following year.

Representatives abroad.—W. de Hedemann, Esq., who had represented the Company in St. Petersburg since 1876, had been forced to retire, owing to failing health, and had been replaced by F. Kiær, Esq.

The proposals that—

(1) "*The report and balance-sheet, together with the propositions as to the distribution of the balance, be adopted and discharge given to the Board of Directors;*"

(2) "*That the retiring Director, Colonel V. Hoskier, be re-elected as member of the Board of Directors;*"

(3) "*That A. Berner, Esq., and S. Bille, Esq., be re-elected as auditors of the Company*"

were submitted to the meeting, and carried unanimously.

Elmore's American and Canadian Patent Copper Depositing Company (Limited).

The first general meeting of this Company was held on Tuesday, at the Cannon-street Hotel, Sir Francis de Winton presiding.

The SECRETARY (Mr. J. Shurmer) having read the notice calling the meeting,

The CHAIRMAN stated that it was simply the statutory meeting which was required to be held within four months after the registration of the Company, and there was, therefore, little or no business to be transacted. They proposed, however, to ask them to sanction an alteration in the Articles of Association in order to comply with the requirements of the Stock Exchange Committee, of whom they had asked for a special settlement and official quotation of their shares. The Committee, however, first of all required them to rescind Clause 92 of the Articles of Association, which was as follows;—

> "92. The Directors shall have full power to execute, in the name and on behalf of the Company, in favour of any Director or other person who may incur or be about to incur any personal liability, whether as principal or surety, for the benefit of the Company, such mortgages or charges of the Company's property (present and future) or uncalled capital as they think fit by way of guarantee to or for the indemnity of such Director or person, and any such mortgage or charge may contain a power of sale and such other powers, covenants, and provisions as shall be agreed on."

The elimination of this clause was entirely in accordance with the shareholders' interest. Out of the 65,000 priority shares offered to the public for subscription, 45,000 had been allotted among 700 applicants, and comparatively a small amount only was outstanding on calls. No time had been lost in obtaining tenders for supplying the plant required to be erected in America to carry out the objects of the Company; and they further hoped, by arrangement with the Directors of the other Elmore companies, to invite the experts of intending purchasers to visit the works of the English and French companies, and thus to show them the real success of the process on a large commercial scale. Difficulties had always to be encountered in putting up new works and starting a new process, but if allowance were made for these drawbacks it would be found that little time had been wasted since the formation of the first Elmore company, and he had no reason to doubt that the English companies were now in a satisfactory condition. If that were the case in one country, it followed that the same could be done in other countries (with proper management) where there was a considerable copper consumption; and he was convinced that in the American and Canadian Company the shareholders had an investment inferior to none of the others. It must be borne in mind that their Company was not formed for the purpose of manufacture, but to exhibit and resell the American and Canadian patents. It was, therefore, most unlikely that there would be any delay in their operations, such as had had to be encountered by the European manufacturing companies. The fully paid share certificates of the Company were ready to be issued in exchange for allotment letters and bankers' receipts. He then proposed the following resolution:—

"*That Clause 92 of the Company's Articles of Association be and is hereby rescinded and annulled.*"

Colonel P. MOSELY seconded the motion.

The CHAIMAN, in answer to a question, stated that, as set out in the prospectus, the Company was formed simply to resell their patents. They proposed to put up a small plant in America in order to demonstrate the practicability and the commercial value of the process; but with the large companies in England and France already working, it would be spending the shareholders' money in a doubtful way to work the process in America.

The resolution was carried, and a vote of thanks to the Chairman brought the meeting to a close.

Western and Brazilian Telegraph Company (Limited).

The following is the report of the Directors to be presented at the twenty-third ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Thursday next, May 12th, at 12 noon:—

The total earnings for the half-year ended 31st December, 1891, amount to £92,345. 4s. 7d., as against £108,817. 10s. 5d., showing a decrease of £16,472. 5s. 10d. compared with the half-year to 31st December, 1890. It will be observed that in common with other South American undertakings the loss on exchange is heavy, and in this Company's case reaches the large sum of £19,133. 16s. 5d. But for this loss the revenue would have been in excess of that for the corresponding period. The working expenses amount to £38,404. 5s. 1d., as against £37,200. 2s. 4d., an increase of £1,204. 2s. 9d.

Including the amount brought forward from 30th June, 1891 (£6,470. 4s. 8d.) and the dividend received upon the shares held in the "Platino" Company, the balance to the credit of the revenue account is £67,798. 4s. 2d. from which has been deducted £12,807 for debenture interest, and £6,293 for the debenture redemption fund, leaving £48,698. 4s. 2d., of which £15,000 has been placed to the reserve fund. The Directors now recommend the payment of a dividend of 6s. per share, free of income-tax, for the half-year on the ordinary shares, making with the dividend paid in November last, £4 per cent. for the year, leaving a balance of £4,486. 18s. 2d. to be carried forward. In the case of shares which have been divided into "Preferred" and "Deferred," 1s. 6d. per share of the dividend now recommended will be payable to the "Preferred" shareholders, and 4s. 6d. per share to the "Deferred" shareholders.

The third annual drawing of the A and B debentures took place at the Company's offices on January 15th last, when debentures amounting to £12,700 were drawn, and have since been paid off at par.

Under a satisfactory arrangement with the Brazilian Submarine Telegraph Company a contact for the immediate duplication for the Company's lines between Santos and Chuy has been entered into with the Telegraph Construction and Maintenance Company (Limited), and the expedition to lay the cable is now on its way out. Upon the completion of this additional line, and in consideration thereof, this Company will receive a payment of £6,000 per annum from the Brazilian Submarine Telegraph Company. When this cable is laid the lines of the Company will be duplicated over the whole of the busy part of the system, namely from Pernambuco to Monte Video; thus affording, in connection with the through lines working in concert with this Company, duplicate lines from Europe to Brazil, Uruguay and the Argentine Republic. The new cable will be duplexed throughout.

The Company has entered into a contract for a new repairing steamer in substitution of the "Norseman." The new ship will be of the best and most recent construction; will be more economically worked, possess greater speed and be more handy in the moderate depths with which the Company will now have to deal. As soon as she reaches her station, efforts will be made to dispose of the "Norseman."

The dividend warrants will be posted on the 13th May, 1892.

The retiring Directors are Mr. C. W. Earle and Mr. D. H. Goodsall, who offer themselves for re election. Notice has been given to the Company that Mr. John Coppen is willing to serve as a Director, and that at the general meeting on the 12th May he will be proposed for election. The shareholders are aware that at the last general meeting the Directors stated that it was not their intention to add to their number, as they did not see their way to fill adequately the place at the Board vacated by Mr. Weave. The Directors are of opinion that the appointment of an additional Director would be of no advantage in the management of the Company's affairs, unless he possessed knowledge and experience of the business of a telegraph and cable company, or special knowledge and influence calculated to be useful to the Company in South America. There is a sufficiency already of general business qualifications at the Board. Under these circumstances, the Directors see no reason to depart from the conclusion announced to the proprietary last November, and coincided in by a fully attended meeting of the shareholders.

The auditors suggest that in future their respective firms should be elected in lieu of themselves as individual partners, and the resolution for the election of auditors should accordingly take this form, viz.:—"That Messrs. Turquand, Youngs, Weise, Bishop and Clarke, and Messrs. Deloitte, Dever, Griffiths and Co., be elected auditors of the Company, and that their joint remuneration (as heretofore) be one hundred guineas."

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NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

ENGINEERING EXCHANGE (LIMITED).—This Company was registered on April 26, 1892, with a capital of £10,000, in £10 shares, to provide, regulate and maintain a suitable building, room or rooms, for an Engineering Exchange or Exchanges in the County of London; to acquire, preserve and disseminate useful information connected with the engineering interest, throughout all markets, and generally to promote engineering business. The signatories are:—Reginald Bolton (5 shares), Arthur T. Salisbury-Jones (5), Wyndham Payne-Gallwey, hydraulic engineer (1), J. J. Dale (1), Fred. B. Nicholson, electrical engineer (1), Charles W. Potter (1), W. J. P. Moore (1).

PAYNE-GALLWEY, PICKERING AND CO. (LIMITED).—This Company was registered on April 26, 1892, with a capital of £20,000 in £1 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to carry on the business of gas, pneumatic, steam, hydraulic and electrical engineers, machinists, iron, brass, and other metal founders, iron, tin, copper, zinc, lead and other plate workers, copper smelters, &c.

SHEFFIELD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This Company was registered on May 3, 1892, with a capital of £98,000, divided into 14,000 shares of £7 each, by Charles Doubble, 14, Serjeants'-inn, Temple, E.C. The objects are to acquire and take over as a going concern the electric lighting and electrical fitting business of the Sheffield Telephone Exchange and Electric Light Company (Limited), together with the assets and liabilities of that Company, and with a view thereto to enter into and carry into effect the agreement referred to in Clause 2 of the Articles. To carry on at Sheffield and elsewhere the business of an electric light company in all its branches, to generate, accumulate, distribute and supply electricity, and to do all things incident thereto. To carry on the business of electricians, mechanical engineers, ironfounders, brassfounders, metal workers, metallurgists, chemists, wire insulators, glass and indiarubber manufacturers, and, if thought fit, the business of a telephone company. The signatories to the Memorandum and Articles of Association are:—John Tasker, Joseph Gamble, George Senior, George Franklin, William Tasker, Frederick Tasker, John H. R. Tasker. The Directors shall forthwith enter into an agreement with the Sheffield Telephone Exchange and Electric Light Company (Limited) in the terms of the draft, a copy whereof has for the purpose of identification been subscribed, and the Directors shall carry the said agreement into effect.

WESTERN COUNTIES ELECTRIC LIGHT AND POWER SYNDICATE (LIMITED).—This Company was registered on April 26, 1892, with a capital of £25,000, divided into 380 ordinary and 120 deferred shares, of £50 each, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to adopt and carry into effect an agreement, dated April 22, 1892, between George J. Parfitt and George J. T. J. Parfitt, of the one part, and Samuel F. Andrews (as trustee for and on behalf of this Company), of the other part, for the acquisition of the business of electrical engineers now carried on by Messrs. George Parfitt and Son, at Keynsham, in the County of Somerset, with all the patent rights, privileges, concessions, contracts, wayleaves, installations, workshops, machinery, plant, &c. To carry on and continue the said business, and generally to carry on the business of an electric light and power company in all its branches. To carry on the business of electrical and mechanical engineers, and manufacturers of and dealers in electric, magnetic, telegraphic, telephonic, and other appliances and apparatus. The signatories are J. H. Clifton, Henry R. Wansbrough, H. A. Hood Daniel, Jno. C. Gilmore, J. Bligh Bond, G. Wilton and Charles Harrison.

MISCELLANEOUS.—BOOTS (LIMITED), wholesale chemists and druggists and dealers in electrical and scientific apparatus; capital, £100,000, in £1 shares.—JOHN WHITELEY AND SONS (LIMITED), wire manufacturers, mechanical and electrical engineers, &c.; capital, £100,000, in £5 shares.—SMOKELESS BOILER AND ENGINEERING COMPANY (LIMITED), boiler and furnace makers, mechanical and electrical engineers, &c.; capital, £100,000, in £5 shares.—T. POTTER AND SONS (LIMITED), general engineers; capital, £20,000, in £1 shares.—WAVERLEY (LIMITED), typewriter manufacturers, mechanical and electrical engineers, &c.; capital, £75,000, in £1 shares.

BIRMINGHAM ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 3, 1892, was filed on April 26th. The Company was registered on December 2, 1889, with a capital of £100,000, in £5 shares. At the time of making up, 17,173 of the 20,000 shares had been taken up, and upon 1,006 of these the full amount had been called, while upon the remaining 7,167 shares, £1 per share had been called. The calls paid amount to £57,174. 10s., leaving £22. 10s. as yet unpaid.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of the above-named Company, made up to October 5, 1891, was filed on March 8, 1892. The Company was registered on August 10, 1889, with a capital of £750,000, divided into 150,000 preference shares, of £2 each, and 150,000 ordinary shares, of £3 each. At the time of making-up 77,978 ordinary and 69,996 preference shares had been taken up. Upon all these shares the full amounts had been called, resulting in the payment of £373,923. 10s., and leaving £2. 10s. as yet in arrears.

DALZIEL'S NEWS AGENCY OF AMERICA (LIMITED).—The statutory return of the above-named Company, made up to April 11, 1892, was filed on April 13th following. The Company was registered on November 14, 1891, with a capital of £100,000, divided into 5,000 "A" and 5,000 "B" shares of £10 each. At the time of making up, 1,500 'A" and 2,500 "B" shares had been taken up, of which 500 "A" and 2,500 "B" shares had been issued as fully paid to Dalziel's Cable News Agency (Limited). Upon the remaining 1,000 "A" shares, £7 per share has been called, resulting in the payment (including £1,302 paid in advance of calls) of £8,148, and leaving £154 unpaid (including £10 due on allotment).

DAVIS AND TIMMINS (LIMITED).—The annual return of the above-named Company, made up to October 20, 1891, was filed on March 11, 1892. The Company was registered on July 25, 1884, with a capital of £10,000, in £10 shares. By special resolutions in 1887 the capital was raised to £20,000 by the creation of 1,000 new shares of £10 each. At the time of making up, 1,253 shares had been taken up, of which 200 fully-paid shares had been allotted to Mr. Emile Davis, and 100 fully-paid up shares had been allotted to Heyne Brothers, of Offenbach, Germany, pursuant to agreements filed. Upon the remaining shares the full amounts have been called, and all calls (£9,530) have been paid.

ELECTRICITY SUPPLY CORPORATION (LIMITED).—At extraordinary general meetings of the members of this Company, on March 29 and April 13, 1892, the following special resolutions were passed and confirmed:—(1) "That the capital be reduced by cancelling the 100 founders' shares of £10 each, which have not been taken or agreed to be taken by any person." (2) "That each of the remaining £10 shares be divided into two £5 shares, upon each of which the amount to be credited as paid up shall bear the same proportion to the sum of £5 that the amount now credited as paid up upon the whole share bears to the sum of £10." (3) "That the capital of the Company be increased to £150,000 by the creation of 200 new shares of £5 each."

GRANGE SYNDICATE (LIMITED).—A notice was filed on April 2, 1892, that Mr. Justice Stirling, on Saturday, March 19, 1892, ordered that this syndicate be wound up, and that Mr. Charles John Stewart, the official receiver attached to this Court, was constituted provisional liquidator. The above-named Company was registered on August 1, 1890, with a capital of £2,000, in £5 shares, to assist in the development and demonstrations of the utility of Groth's electric tanning system. The last annual return, made up to January 13, 1892, and filed on January 21st following, shows that 330 of the 400 £5 shares had been taken up, the full amount called, and £1,550 out of £1,650 paid.

HASTINGS AND ST. LEONARD'S-ON-SEA ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 9, 1892, was filed on February 15th following. The Company was registered on March 7, 1882, with a capital of £50,000, in £10 shares; and, at the time of making-up, 843 shares had been taken up, and the full amount called. The total amount received, including payments on application and allotment, is £8,385, and the calls unpaid amount to £45.

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to April 19, 1892, was filed on the 29th. The Company was registered on February 20, 1888, with a capital of £350,000, divided into 57,900 ordinary, 12,000 preference, and 100 founders' shares of £5 each. At the time of making-up, 8,322 ordinary, 2,800 preference, and 100 founders' shares had been taken up, of which the founders' and 1,000 ordinary shares had been issued as fully paid. Upon the remaining 7,322 ordinary and the 2,800 preference shares, the full amount had been called, resulting in the payment of £50,210, and leaving £400 in arrears.

NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED.)—The annual return of the above-named Company, made up to April 14, 1892, was filed on April 28th following. The Company was registered on February 21, 1888, with a capital of £100,000, divided into 9,450 ordinary shares of £10 each, and 550 founders' of £10 each. At the time of making-up, 6,452 ordinary and 550 founders' shares had been taken up. Upon all of these the full amount has been called, and as a result all the calls (70,020) have been paid.

CITY NOTES, &c.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—Notice has been given this week of the first drawing of 5½9 Four per Cent. Debentures, which took place yesterday (Thursday) at the offices of the Company.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 1st were £794, as against £733 for the corresponding period of last year, being an increase of £61. The total receipts to date, from January 1st last, amount to £14,418, against £13,247 in the corresponding period of 1891, being an increase of £1,171.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of April were £3,700, as compared with £3,760 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the month of April amounted to £1,785, as compared with £1,825 in the corresponding period of last year, a decrease of £40.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of April amounted to £53,683, as against £60,909 in the corresponding period of last year, a decrease of £7,226.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of April amounted to £38,824, and to £44,729 in the corresponding period of last year, a decrease of £5,905.

ELMORE'S AMERICAN AND CANADIAN PATENT COPPER DEPOSITING COMPANY (LIMITED).—Application has been made to the Stock Exchange

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to appoint a special settling day in, and to grant a quotation to 44,788 priority shares in this Company.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED).—It is stated that the letters of allotment of the Ten per Cent. Preference shares of this Company have been posted.

GREAT NORTHERN TELEGRAPH COMPANY.—The distribution of 7s. 2d. per £10 share, representing the final dividend for 1891, is now payable at the Company's bankers, Messrs. C. I. Hambro and Son, 70, Old Broad-street, London, E.C., against coupon No. 24. The traffic receipts of this Company for April, 1892, amounted to £20,000; and from January 1st to April 30th to £82,800. In the corresponding months of 1891 and 1890 the amounts were £88,000 and £81,800 respectively.

MESSRS. MIX AND GENEST (LIMITED).—At the annual meeting of the shareholders of this Company, recently held at Berlin, a dividend of 6 per cent. was declared.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended April 29, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,275.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the fortnight ending April 30, 1892, amounted to £2,669, as compared with £2,984 in the corresponding period of last year, a decrease of £315.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, April 27.		Price Wednesday, May 4.		Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending May 4.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	48½	49½	48½	49½	5 6 1	Jan., Apr., July, Oct.	48¾	..
£2,849,510	Stock	25/0	Do. Preferred	87½	88½	87½	88½	5 17 4	" "	88½	87½
£2,849,510	Stock	5/0	Do. Deferred	11	11½	11	11½	..	" "	11⅝	11 7/16
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¾	11¼	10½	11	7 5 6	Mar., June, Oct., Dec.	11	10½
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	155	160	155	160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	10½	11½	10½	11½	6 19 2	February and August	11½	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3¾	3½	3¾	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	8½	9½	8½	9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11½	11¾	11⅝	11⅞	6 0 2	Jan., Apr., July, Oct.	11⅝	11 7/16
400,000	10	2/6	Eastern	14⅜	14½	14⅜	14½	4 10 5	" "	14½	14 11/16
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15⅜	15½	3 16 2	" "	15⅝	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.. xd	109	112	107	110	3 12 9	May and November	110	108
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	108	..
250,000	10	2/6	Eastern Extension	15	15½	15⅜	15⅝	4 11 1	Jan., Apr., July, Oct.	15⅝	15⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 8	January and July ..	..	..
£185,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	106	102	105	4 15 3	" "	102½	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1900 (regd.)	99	102	100	103	3 17 8	February & August	102½	..
180,227	10	2/6	Globe Telegraph and Trust	10	10½	10	10½	5 2 5	Jan., Apr., July, Oct.	10½	10 1/16
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15½	15⅝	3 18 1	" "	15⅝	15½
150,000	10	5/0	Great Northern	18¾	19¼	19	19½	4 7 2	Jan., April, and July	19½	19⅜
£320,000	100	5%	Do. 5 per Cent. Debentures, 1863	105	108	106	109	4 11 9	March & September	108½	108
17,000	25	37/6	Indo-European	41	43	39	41	6 1 11	May and November	41	39½
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	6	7	5½	6½	6 3 1	April and October..	6 1/16	5½
3,331	£100 Cert.	1½	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	115⅛	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	100½	99½
30,000	10	2/0	West Coast of America	2½	3½	2½	3½	..	January and July ..	3	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama	1⅜	1⅝	1⅜	1⅝	..	" "	1 1/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10½	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
67,007	15	6/0	Western and Brazilian	10	10½	9½	10	7 10 5	" "	9⅝	9½
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	3½	4	..	" "	3⅞	3½
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	105	108	5 11 1	February & August	..	..
€237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	104	107	105	108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage xd	118	122	115	119	5 17 8	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	6 0 0	March & September	100½	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	7/16	7/16	9 13 6	May and November	7/16	⅜
x20,000	£1	4½d.	Oriental (11s. paid) xd	½	⅝	7/16	7/16	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅜	4⅝	4½	4⅝	6 13 4	June and December	4 7/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	13	13½	4 8 11	" "	13½	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12	12½	12	12½	4 16 0	" "	12½	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	107	109	107	109	4 2 7	January and July ..	107½	107½
58,000	5	1/0	United River Plate	2	3	2	3	..	" "	..	..
£146,870	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7½	8	7½	7⅝	..	—	7⅝	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	5½	5⅝	2½	3½	..	—	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	..	5½	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5½	6	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	2⅝	3	3⅜	3½	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5	5½	5	5½	..	March	..	..
111,000	5	..	London Electric Supply	⅞	1⅛	⅞	1	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8½	8¾	7⅞	8	..	..	8 1/16	7⅞
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½	5½	4½	5½	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8½	8¾	8½	8¾	—	..	8 1/16	..
7,900	£5	7%	Do. 7% Preference	7½	8	7½	8¼	..	..	8	7⅞
42,853	5	..	Westminster Electric Supply (fully paid)	6⅞	7	6⅞	7	..	..	6⅞	6 7/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1 9	Brush Electrical Engineering	2	2½	3	3½	..	..	..	..
69,996	2	6%	Do. 6 per Cent. Preference	2	2½	2	2½	5 2 7	..	2 1/16	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	5¾	5½	5¾	5 16 8	January and July ..	5¾	..
17,130	5	17½	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	5½	6½	5½	6½	..	—	6 3/16	6 1/16
70,000	2	10/0	Elmore's Patent Copper Depositing	2½	2¾	2½	2¾	—	—	2¾	2⅝
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½	20½	20	21	5 19 0	February & August	20⅜	20⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	102	105	4 5 9	March & September	104	..
11,334	£10	6/4	International Okonite Limited Ordinary	4½	5½	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 18 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	6/0	8/0	⅛	¼	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	3½	4¼	3⅝	4¼	9 0 9	May and November	4	..
36,250	12	36/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 1	March and July	43½	42⅜
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	..	⅛	¼	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	..	..	2½	3	..	—	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
40,000	£10	—	City and South London Railway	3½	3¾	2½	3½	—	—	..	..

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NOTES.

While wishing every success to the Central London Railway, and valuing the staunch advocacy of electric traction by Mr. Greathead, we regret to see that he, unlike the London County Council, does not think that it is desirable that the lines should be made capable of taking ordinary existing rolling stock. The South London line was, of course, an experiment. It was built with remarkable economy, and the small size of the tubes and carriages contributed, no doubt, to the low cost. But it seems a mistake to build anything that can be called a railway, or even that can be used as a railway, to any other gauge than the standard 4ft. 8½in., and to any dimensions that will prevent the use of ordinary rolling stock This country is not yet quite played out; and it is as rash to attempt to forecast the possible extensions and development of electric railways, and whether or no it may some day be desirable to make junctions, as it was when Brunel stuck to his broad gauge, little dreaming of the troubles that would arise, or of the huge expansion of the railway system which would be embarrassed. If the possibility of an invasion is a serious objection to the construction of the Channel tunnel that same objection applies to a break of gauge or other impediment to through traffic. The possibility of pouring an army through London in any direction seems to be worthy of some consideration.

The progress of the Metropolitan Electric Supply Company, now the leading electricity supply company in the United Kingdom, will be watched with considerable interest by electrical engineers in this country, the system adopted being fairly typical, and the area served an average one. At the present moment the Metropolitan Company has 1,000 customers upon its books and nearly 100,000 lamps connected to its mains; it has succeeded in paying a 2 per cent. dividend; and having annexed the huge district of Paddington, an annexation not originally contemplated, it proposes to meet the outlay involved by a debenture issue. The text of the Chairman's speech was patience; and in the case of the Metropolitan Company there seems a reasonable probability that this virtue will not be without its reward.

It is instructive to note how the difference of system and environment affects both the apportionment of capital outlay and the various items of annual expenditure in the case of two typical supply companies such as the St. James and Pall Mall and the Metropolitan. In the revenue account for 1891 there is only one item, namely, rent, rates and taxes, and miscellaneous charges, which bears the same percentage proportion, viz., 9·2, to the year's expenses of the two concerns. A comparatively lightly-loaded plant and a multiplicity of stations probably account for the generating expenses of the Metropolitan Company amounting to over 78 per cent. of its total annual outgoings, as against 65 per cent. in the case of the St. James Company. On the other hand, when we come to capital expenditure, the high-pressure system may fairly be credited with the fact that the Metropolitan Company's outlay on lands has been only £12,388, or 2·5 per cent. of its total capital expenditure, as against 21·4 per cent. for the St. James Company; similarly, the outlay on mains has been respectively 22 per cent. and 31·5 per cent. of the total. An engineer's report would have been a particularly interesting supplement to the report, on account of the great variety of plant used, and of districts supplied by this Company.

"The Strange Adventures of an Electric Current" might have formed the title of Major Cardew's recent reports upon certain cases of damage in the district of the St. James Company. The report, which will be found elsewhere, attaches great importance to the presence of pilot wires in the culverts, but the explanation does not seem to be quite satisfactory. One of the most difficult problems of continuous-current supply is to localise leaks and earths on the mains. The careful night inspection of water supply has effected a most important saving in several cases, but the water, at the worst, only ran away into the soil or the drains. It is very probable that more damage by electrolysis has been done by leaks on electric supply systems than has yet been discovered. A development of the night-testing system, in which various feeders, mains, and consumers are disconnected during the small hours, seems to be the best way of localising faults.

As Mr. Nikola Tesla, without giving any satisfactory explanation for so doing, survived, after placing himself in circuit with many thousands of volts, magazine writers and other irresponsible dishers-up of scientific trifles have asserted that if lower frequencies had been employed the genial lecturer would have been volatilised, deflagrated, or otherwise distinctly and permanently inconvenienced. High-pressure experiments are just now very much *à la mode*. Messrs.

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Siemens Bros. and Messrs. Swinburne and Co. are day after day wasting the valuable time of Messrs. Simpson and Fox-Bourne and adding to the attractions of the Crystal Palace Exhibition; while at the Royal Society *conversazione*, Dr. Bottomley, Prof. J. Crookes, Prof. Oliver Lodge, Mr. Wimshurst, and Messrs. Pyke and Harris, exhibited high-pressure discharges in various forms.

Quite as attractive and popular as the phonograph, and, it may be added, with as little promise, at present, of scientific or commercial importance, high-pressure discharges round a sheet of glass and the illumination of vacuum tubes without wires promise to be indispensable at any afternoon party. That bugle-call and the other phonograms have indeed become rather stale, and interest might well be gathered round the 100,000-volt discharge, which is "fifty times greater than the current used for American executions, don't-you-know." When the pretty experiments begin to pall, say, at the close of the season, excitement might be revived by allowing fair sight-seers to touch one terminal of the coil, and when this fails to draw, they might be allowed to "take the whole current," as the engineer was wont to do when he grasped the 110-volt terminals of the Edison dynamo in the old plant at Holborn Viaduct.

Many of the Crystal Palace experiments really take a considerable amount of power, but it is time that the mystery surrounding the vacuum-tube lighting was dispelled. The *Electrical World* of New York has made the difficulties, such as they are, apparently greater than they were, by constructing four questions, which were propounded to various authorities, eminent and otherwise. Had the questions been carefully considered, they could hardly have failed to elicit something worth reading, but they seem to have emanated from some one who had never heard of impedance.

Messrs. Swinburne and Co. and others have forced one or two horse-power through vacuum tubes for a few seconds; that is one of the new experiments. Another is to cause vacuum tubes to glow when held in the hand. But no one has yet given any idea of the current in either case. The great, and perhaps only, defect of Mr. Tesla's lecture was the absence of any quantitative information. Returning to the method of electrical measurement adopted by Cavendish, who estimated the magnitude of discharges by the shock felt, there is no doubt that an ordinary schoolboy's vacuum tube, illuminated to a fair drawing-room or *conversazione* degree, takes less than one milliampere and probably not more than one-tenth of that current. Mr. L. Pyke estimates that each foot run of ¼in. tube takes about one watt. The measurement of small alternating currents is rather difficult, but we hope some one will give attention to it. Quantitative measurements of small alternating currents are greatly needed also to place medical work upon a sound basis.

In the opinion of more than one authority on dynamo construction, the alternate-current machines of the future are likely to be built on the inductor principle. There is, fortunately, no master patent. Mr. Mordey has suggested more than one form of rotating-keeper dynamo, Mr. Kingdon has built several, and Mr. Rankin-Kennedy has given considerable attention to the subject. The machine to which we alluded last week, and of which we now give further particulars, presents many of the advantages of the type. The chief difficulty of an electrical nature is the heating. The mechanical difficulty in the present example is the carrying of the inductors with sufficient rigidity. The clearance in inductor machines ought to be very small, the "*entrefer*" being a mere air-gap, and containing no copper. There seems to be a choice between the overhanging keepers of Messrs. Pyke and Harris, passing between opposing pole faces, or the simple drum of Mr. Kingdon, with pole faces ranged side by side, or a radial arrangement. The last would necessitate the use of thrust bearings. The Pyke and Harris machine might be duplicated, with inductors projecting on each side of a driving disc, but mechanical equilibrium would thus be attained at the cost of ventilation and armature resistance. In the absence of armature-winding and commutators, the mechanical construction is a simple engineering job. High-speed drums running with small clearance present little difficulty, and we hope to hear more of this type of dynamo.

Antwerp.—It is proposed to hold an International Exhibition in Antwerp in 1894.

Royal Society.—The Papers down for reading yesterday included one on "Transformers," by Prof. Perry.

India-rubber.—Steps are being taken to develop the resources of the Upper Congo in the matter of india-rubber.

The Works of Prof. Weber.—The Royal Society of Gottingen are going to publish the works of Prof. W. Weber.

Monte Video.—It is stated that application has been made to the Monte Video Municipal Board for authority to establish a new telephone company, with subterranean wires.

Personal.—Our Glasgow correspondent informs us that Mr. William Buchanan, B.Sc., Whit. Sch., has been appointed electrical engineer to the London Electric Supply Corporation, on the recommendation of Lord Kelvin.

Cable Interruptions.—The following lines are actually interrupted:—

	Date of interruption.
Siberian land-lines	7th May.
Bolama-Bissao Cable	23rd April.

The Electric Lighting of the International Horticultural Exhibition.—A reward of £100 is being offered to any person giving such information as will lead to the conviction of those who did wilful damage to the electrical appliances of this Exhibition on Saturday evening last.

Institute of Chemistry.—A Conference of the members of this Institute will be held at the rooms of the Chemical Society, Burlington House, at 3 p.m. on Monday, May 16th. The subject for discussion will be "The present Regulations with respect to the Admission of Fellows and Associates to the Institute."

Nottingham.—The Electric Lighting Committee of the Town Council have had under their consideration applications for the post of electrical engineer in Nottingham. The salary offered was £300 per annum. There were 147 applicants. The post has been offered to Mr. H. Talbot, engineer to the Chelsea Electricity Supply Company.

The Electric Lighting of the City.—The City of London Electric Lighting Company intimate that applications for supply

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have become so numerous that they must limit, during the next twelve months, the number of connections. Preference will be given—1, to premises already wired; 2, to premises for which guarantees to take current have been signed.

Breslau.—The results of the first half-year's working of the Breslau central station show receipts amounting to £7,500, the expenditure, including the writing off of 6 per cent. of the capital outlay, being £6,250. The total capacity of the station is 14,000 lamps, and at present 10,800 are wired. An extension of the system is being proposed, water power being available close to the town.

Portsmouth.—The Corporation Electric Lighting Committee have decided to adopt, for the lighting of the streets, Swan-Edison lamps of 200 c.p., which will be placed at distances of about 50 yards. The existing gas columns, which stand about this distance apart, will be used for the new lamps in almost every case. The Clarence Esplanade, from one pier to the other, will be illuminated by Brockie-Pell arc lights.

The Proposed International Electrical Congress at Chicago.—The following are some of the European men of science who have consented to act on the Advisory Council of this Congress:—Lord Kelvin, Mr. W. H. Preece, Prof. W. E. Ayrton, F.R.S.; Lord Rayleigh, Prof. S. P. Thompson, Prof. E. Mascart, M. E. Hospitalier, Dr. Werner Siemens, Prof. H. von Helmholtz, Prof. Galileo Ferraris, Prof. E. Gerard, and Prof. A. Stoletow.

Electricity and Gas at the Vienna Town Hall.—During the year 1890-91 nearly 9½ million cubic feet of gas were consumed in this building, giving a little over 21 million candle-hours, which, at 4s. 6d. per thousand, comes to 0·4d. per 16 candles per hour. The electric light cost £933, and some 20,000 units (B.T.U.) were used, which, at 55 watts per 16-candle lamp, works out at 0·615d. per 16 candles per hour, as against 0·638d. for the previous year.

Smoke Prevention.—A test of the combined apparatus of Messrs. Greaves and Sennett as applied to steam boilers has, says *Industries*, been recently made. Mr. Greaves' invention consists of fireclay arches through which the combined gases and air are passed, and which becoming incandescent cause the smoke to be consumed. Mr. Sennett's principle is the induction of a low-pressure current of air by means of steam jets, and the two devices combined give a very good result.

Société Internationale des Électriciens.—The following gentlemen form the council of this society for the current year: President, M. L. Raymond, Director of the Ecole Supérieure de Télégraphie; vice-presidents, MM. Bouillhet and Potier; secretaries, MM. Sarcia and de la Touanne; members of council, MM. Abdank-Abakanowicz, Baille, Baudot, H. Becquerel, J. Boulanger, Brüll, Cance, Cornu, Fribourg, Friedel, Gaudry, Hillairet, Krebs, Meyer, Mildé, Raffard, Tripier, Vaschy, Violle, and Vlasto.

Crystal Palace Electrical Exhibition.—Popular experimental demonstrations are being given on Wednesday evenings at 8.30 in the theatre of the Palace by Dr. J. A. Fleming. The subject chosen by Dr. Fleming is "Electro-Magnets and Electric Currents: their Production and Use." Views are given by means of a large Brockie-Pell arc-light lantern, arranged by Mr. T. C. Hepworth. The first of these lectures was delivered on Wednesday evening last; others will be given on May 18, 26, and June 1.

Deputation to the Postmaster-General.—A large deputation from the Associated Chambers of Commerce will wait on the Postmaster General to-day, for the purpose of urging, among other things, the reduction of the inland registration fee to one penny, the extension of the postal order system to all Colonies and British Possessions, and the cheapening of telegrams by reduction of price, or by allowing addresses to be sent free. The deputation will also recommend that the Government should take over the telephone system, and that telegraph wires should be protected by being laid underground.

Montreal.—The Royal Electric Company of Montreal, says the *Electrical World*, has in contemplation some very important plans for increasing the capacity of its plant. The Company contemplates the utilisation of the Chambly Rapids, and as soon as the water is low enough operations are to be commenced. The rapids are susceptible of developing, it is estimated, at lowest water, over 20,000 H.P. Once the work is commenced it is to be carried on vigorously, and by the end of the present summer one-third of the power, it is expected, will be developed. It will probably be two years before the full power has been developed.

Aluminium.—A company has been formed in Philadelphia, says *Industries*, for the purpose of manufacturing aluminium by a new process discovered by Mr. Edward C. Broadwell. By this process, which is both electrolytic and chemical, it is claimed that 5,000lb. of aluminium can be made with the expenditure of 5,000 E.H.P.H. It is also claimed that the finished product can be sold at 15c. per pound, with a slight profit, which is about the same as the price of copper, and about one-fourth of the present price of aluminium. The Company is known as the American Aluminium Company, and has a capital of £400,000.

The Electrical Utilisation of Water Power.—An interesting hydro-electric power station is approaching completion between Herrenwiesen and Bülach. Three canals, two starting from the left and one from the right bank, have been dug. The first one on the left is 215 metres long, and will give from 380 to 400 H.P. under a head of 11 metres. This power is to be transmitted by electricity to the Oerlikon works, nine miles off. The second canal on this bank is 66 metres long, and also gives a fall of 11 metres. The third canal gives 70 H.P., which is to be electrically transmitted to Bülach and there supply power to some glass works, a saw mill, a flour mill, and a central lighting station.

Obituary.—We regret to have to record the death of Dr. James Thomson, brother of Lord Kelvin, and Emeritus Professor of Civil Engineering in Glasgow University. Prof. Thomson was born in Belfast in 1822, and chose the profession of a civil engineer, serving his apprenticeship in the works of the late Sir William Fairbairn. In 1857 he became Professor of Civil Engineering in Queen's College, Belfast. In 1872 he was elected to fill the Glasgow chair. Prof. Thomson maintained his zeal for scientific pursuits, and in March of this year he completed a Paper on the grand currents of atmospheric circulation, which was chosen by the Royal Society as Bakerian Lecture for the year.

The Dissipation of Heat in Armatures.—At a recent meeting of the Société Internationale des Électriciens, M. Rechniewski gave the results of some investigations by M. Labour and himself, on the relations between energy dissipation in and cooling surface of dynamo armatures. M. Rechniewski allows a raise of 50°C. above the temperature of the surrounding atmosphere. The figures he arrived at in the case of three 2-pole drum machines were 7·14, 6·9, and 7·5 sq. cms. per watt dissipated. With vigorous internal ventilation, only 4·25 sq. cms. need be allowed. Finally, in certain armatures of multipolar machines with open interiors and vigorous ventilation, M. Rechniewski concludes that 3·3 sq. cms. per watt dissipated will suffice.

A Bismuth Battery.—If two bismuth electrodes are plunged into a vessel containing a solution of bismuth-chloride, or of hydrochloric acid, and if one of the electrodes is placed between the poles of an excited electro-magnet, a galvanometer will show that an electric current flows in the liquid from the magnetic electrode. This current is always in the same direction. The electro-motive force varies with the electrodes and the solutions; in certain cases it may attain ·0023 Daniell when the magnetic field = 81500 H (H = horizontal component of the earth's field). This current, says G. P. Grimaldi in *Il Nuovo Cimento*, Vol. XXV., p. 191, is due partly to the motion of the diamagnetic liquid, which is caused by the magnetic field, and it also seems to depend on the peculiar effect which magnetism appears to have on the position of bismuth in the electro-contact series

Trolley Accident at Marseilles.—Just as the overhead trolley line at Marseilles, on which numerous experiments have lately been made, was about to come into regular operation, an

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accident has occurred which will probably delay the matter some time. The conductors are carried on insulators which are hung from transverse iron wires attached to wooden posts on either side of the double track. In order to guard against the possibility of telephone wires making contact with the trolley line, the Government insisted on insulating forks being arranged so that protecting wires carried by their arms should run exactly over the trolley wires. The accident arose from the trolley "jumping" the line and striking against the guard wires, bringing a length down on to the "live" wires below, and on to a dog and a horse on the ground, with the result that these animals were killed by the 550-volt current.

The British South Africa Company's Telegraphs.—The extension of the British South Africa Company's telegraphs has been carried on under the direction from Cape Town of Mr. Stanford, the assistant superintendent of telegraphs, and offices have been opened at:—

	Date of opening. 1891.	Length of sections. Miles.
Macloutsie	13th May	89
Tuli	28th May	50
Nuanetsi	9th Sept.	97
Victoria	31st Oct.	71½
	1892.	
Charter	18th Jan.	110¼
Salisbury	16th Feb.	61½

This completes the construction work inaugurated by the Company in 1890—a total distance from Mafeking of 772¼ miles.

The Deptford Station.—"Through excess of zeal accompanied by lack of discretion, a hunter," says the *Electrical Engineer* of New York, "once upon a time found himself in the position of having an exceedingly lively tiger by the tail, and was thereupon confronted with the awful conundrum as to whether he would do worse to hold on or to let go. This appears to be be substantially the situation which now confronts the London Electric Supply Corporation, organised four years ago to produce and distribute electricity on a colossal scale, as if, like the brewing and sale of beer, it was simply a question of a sufficiency of working capital. . . . One cannot but admire the true Anglo-Saxon pluck with which the shareholders of this ill-starred undertaking have stood by their colours, and still stand by them. . . . One cannot but hope that the undertaking may be attended with at least a reasonable degree of success. Such splendid courage deserves a happier issue than has so far attended the venture."

Taunton.—A special meeting of the Town Council was held on Tuesday last week to receive and consider the report of Mr. Gisbert Kapp, who has been employed by the Council to make a valuation of the Taunton Electric Lighting Works, which the company owning them have offered to the Council for the sum of £10,000. Mr. Kapp reported that the present system (the Thomson-Houston) was not suitable for small areas. For various reasons he could not advise the Council to buy the undertaking as a going concern. Taunton could be lighted most economically on the direct-current low-pressure three-wire system, with batteries to take the day load. If they determined to utilise the existing station the Council could take over the buildings, boilers, engines, and accessories, and 44 iron posts, paying the company £5,250. The Council expressed an opinion greatly in favour of continuing the present system, and it was agreed that the consideration of Mr. Kapp's report should be postponed until the next meeting of the Council.

The Azores Cable.—The Lisbon correspondent of *The Times* writing under date May 10th, says, "To-day's *Diario* contains an announcement inviting tenders, to be handed in by the 25th inst., for the construction and working of cables from Lisbon to all the principal Azores Islands. Provision must also be made for the continuation of the cable to Flores Island and North or Central America, and also for constructing a cable from Lisbon to a point on the Continent of Europe. A provisional deposit of £10,000 must be made for the privilege of competing, besides one of £20,000 in the event of the tender being accepted. The scheme of construction is based principally on the clauses of the contract entered into last February between the Portuguese Government and the British Company; but it has apparently been modified so as considerably to facilitate a tender from the French syndicate, and I understand that in any case it does not admit of such advantageous terms for Portugal as those lately offered by the British Company. The matter appears to have an international importance."

Non-Arcing Metals.—In the course of some exhaustive investigations on lightning protectors, Mr. Alexander J. Wurts, of New York, lighted upon several combinations of non-arcing metals. Mr. Wurts's theory of the action of non-arcing metals is that a vapour of high resistance is momentarily projected between the poles, breaking the arc. In this connection Mr. McCay writes to the *Electrical Engineer* of New York, of April 13th, stating that while working several years ago in Berlin, under Prof. Helmholtz, he obtained the purest possible mercury and zinc, and made amalgams, and in every case found that they decreased in resistance. Mr. Wurts, in the Paper which he read before the American Institute of Electrical Engineers on March 15th last, said he found that the *paste* made from zinc and mercury was an arcing metal, while pure zinc and mercury were non-arcing. Mr. McCay considers this fact a striking corroboration of Mr. Wurts's hypothesis. The resistance of zinc and mercury both increase with the temperature; but as the electrical resistance of zinc-mercury amalgams does not follow the usual law of alloys, it is highly probable that the resistance *decreases* with high temperatures, and it would therefore follow, on Mr. Wurts's theory, that the paste would arc.

Electricity in Mining.—A meeting of the Association of Belgian Mining Engineers was held in Liége on the 7th inst., at the new Montefiore Electrical Institute. The chair was taken, in the unavoidable absence of M. Montefiore, by M. Dechamps, the President, who opened the proceedings by introducing to the meeting Mr. Llewelyn Atkinson, of London, and Mr. D. Selby Bigge, of Newcastle-on-Tyne. Mr. Walton Brown, Secretary of the North of England Mining Institute, who had hoped to be present, was prevented at the last moment from coming. After an interesting description by Prof. Eric Gerard of the Institute and its work, Mr. Selby Bigge read a Paper "L'Application de l'Électricité dans les Travaux des Mines." In the course of his lecture the author referred to the important question of safety in mines, and described the various precautions taken by Messrs. W. T. Goolden and Co. in the manufacture of their electric mining machinery, and by himself in the laying down of the same. The whole company present then visited the fine laboratories and workshops of the Institute. It is interesting to note that the whole of the internal wiring of the Institute is carried out by wires twisted together to avoid the influence of the current upon delicate instruments used.

An Electrolytic Experiment.—In *La Lumière Electrique* for March 19th the following electrolytic experiment is described: it is due to Herr Arons, and was shown by him to the Berlin Physical Society. If we place a hollow copper cylinder between the electrodes of a sulphate of copper voltameter, copper will be deposited on the cylinder where the current enters it, and dissolved where it leaves. If the cylinder is free to turn about a horizontal axis, it will commence to rotate as soon as the current passes, owing to the surface next the anode becoming weighted. It is possible to arrange matters so that the specific gravity of the cylinder is only a trifle greater than that of the solution, and hence the pressure of its axis upon the supports may be indefinitely reduced. The containing vessel used by Herr Arons was a glass box. The copper cylinder, which occupied nearly the entire width of the containing vessel, was 4·5cm. long, and 10cm. in diameter, and the walls were about 1·8mm. thick. The spindle was formed by a glass rod 1mm. in diameter, secured to ebonite plugs fixed into the cylinder; the spindle rested on ebonite supports, attached to the walls of the containing vessel. The cylinder turned slowly and continuously under the influence of currents varying from 0·1 to 1 ampere. Experiments showed that the speed of rotation was very nearly proportional to the current.

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A Standard Condenser.—In the *Comptes Rendus* of March 21st, M. Abraham described a standard air-condenser constructed by him with a view to a fresh determination of *v*. The capacity was about 500 C.-G.-S. units (electrostatic). The plates consisted of two circular slabs of Saint-Gobain plate glass, 2·3cm. thick and 35cm. in diameter, both faces and all the edges being completely silvered over. The opposing faces were accurately planed. One of the plates rested on cloth pads, supported on paraffin supports. The silvered surface of the other disc having to be divided into a collecting plate and a guard-ring system, a circle 22cm. in diameter was cut in it by means of the steel burin of a circular dividing engine, a clean cut 0·1mm. broad being effected. This same plate was pierced at the centre with a hole 2·5mm. in diameter, widened out into a cone towards the planed surface. The interior of this cone was silvered, and its end stopped with an accurately-fitting silver plug, to which was soldered the wire connecting the condenser with the measuring instrument. The guard-ring plate was separated from the other plate by three accurately-turned quartz washers, arranged to come underneath the guard-ring. The insulation afforded by the quartz washers was found to be excellent. The insulation resistance of the groove cut in the plate was over 80,000 megohms. With the width adopted for the guard-ring (6·5cm.) the correction for edge influence was less than $\frac{1}{30000}$th, even when the plates were 1cm. apart. The linear dimensions of the condenser were all measured by a standard dividing engine.

Telegraphic Communication with Lighthouses and Lightships.—In the course of his Paper on "Electricity in the Navy," read last week before the United Service Institution, Lieutenant F. T. Hamilton said that one use of the telegraph that we were at present hearing a great deal about was for communication with outlying lighthouses and lightships. There were two difficulties in the way. A plan had, however, been devised by the Telegraph Construction and Maintenance Company, by which communication could be made to both lighthouses and lightships without the cable actually going on board them. A twin cable was led out from the shore to within a quarter of a mile of the lighthouses or ship. The cores were then forked out, and ended in large earth plates about a quarter of a mile apart, one on either side of the place to be telegraphed to. Two earth plates were put overboard, one from either end of the lightship, or on either side of the lighthouse. If Morse signals were now sent along the twin cable from the shore they could be distinctly heard in a telephone on board the lightship. The plan was under trial, and was likely to get over the difficulty of communication. But the second difficulty was not so easily disposed of. At present lighthouses and lightships were supposed to be exempt from attack in war time, but if we had telegraphs to them it would be a sore temptation to use them as outlying signal stations for reporting the enemy's movements; and even if our morality were proof against the temptation, what enemy was going to give us credit for such correct behaviour?

The Utilisation of Wind-Power.—In an article on this subject in *La Lumière Electrique*, M. G. Pellissier points out that we obtain far more mechanical power from the movements of the atmosphere than is generally supposed. For instance, last year the tonnage of the sailing fleet of the world amounted to four and twenty millions, and to these vessels must be added the thousands of windmills at work in Europe and America. Nevertheless, many long-established windmills have been and are being replaced by steam power, and the few instances of the application of wind-power to dynamo-driving have not proved economically encouraging. The main cause of this is the great irregularity of aerial currents both in direction and velocity. Recent experiments at the top of the Eiffel Tower have, however, shown that at moderate altitudes these irregularities tend to disappear. In Vol. XXXVIII. of the *Annuaire de la Société Météorologique de France* M. Angot publishes the results of observations made simultaneously at the top of the Eiffel Tower (305 metres) and at the Bureau Central Météorologique (500 metres distant from the tower) at an altitude of 20 metres. Figures given by M. Angot show that the speed of the wind at a height of 305 metres is on the average some three times as great as it is at an altitude of 20 metres, its direction being at the same time more constant. Considerable advantages, therefore, accrue from placing windmills at moderate altitudes. At the meeting of the British Association at York in 1881 Sir William Thomson discussed the subject of the utilisation of wind-power, and came to the conclusion that so far, at any rate, as its electrical utilisation was concerned the thing was out of the question by reason of the high prime cost and poor efficiency of the windmill. This conclusion has been traversed by a Mr. A. R. Wolff, who is of opinion that the windmill is the most economical of all prime motors where small powers are to be dealt with; the impossibility of the extensive electrical utilisation of wind-power being, according to him, due solely to the poor quality of the modern accumulator. However this may be, says M. Pellissier, coal is destined to disappear, and the utilisation of wind-power becomes daily more important.

Royal Society Selected Candidates.—Among the 15 candidates selected on Thursday, May 5th, by the Council of the Royal Society, to be recommended for election into the Society on June 2nd, we note the names of Dr. J. A. Fleming, Mr. J. Larmor, and Lieut.-Col. R. Y. Armstrong, R.E. The following are the statements of the qualifications of these candidates:—John Ambrose Fleming, M.A. (Camb.), D.Sc. (Lond.). Prof. of Electrical Engineering in University College, London. Late Fellow of St. John's College, Cambridge. Fellow of University College, London. Some time Demonstrator in Applied Mechanics in the University of Cambridge. Author of the following Papers, among others:—"The Polarisation of Electrodes in Water free from Air" (*Proc.* Phys. Soc., 1874); "A New Form of Resistance Balance" (*Proc.* Phys. Soc., 1880); "On the Characteristic Curves and Surfaces of Incandescent Lamps;" "On Molecular Shadows in Incandescent Lamps;" "On the Use of Daniell's Cell as a Standard of Electro-Motive Force;" and "Problems in the Distribution of Electric Currents in Networks of Conductors" (*Proc.* Phys. Soc., 1885); "On the Necessity for a National Standardising Laboratory for Electrical Instruments" (*Proc.* Inst. Elect. Engs., 1885); "A Design for a Standard of Electrical Resistance" (*Proc.* Phys. Soc., 1889); "On Electric Discharge between Electrodes at Different Temperatures in Air and in High Vacua" (*Proc.* Roy. Soc., 1889; "On Some Effects of Alternating-Current Flow in Circuits having Capacity and Self-Induction" (*Proc.* Inst. Elect. Engs., 1891). Delivered Friday Evening Discourses at the Royal Institution, 1890-91. Author of "Short Lectures to Electrical Artisans," four editions, and of "The Alternate-Current Transformer in Theory and Practice."—Robert Young Armstrong, Lieut.-Colonel R.E., from 1870 to 1875 was Assistant-Instructor in Submarine Mining and Electricity, and from 1875 to 1882 was Instructor. From 1884 to the present date, Inspector of Submarine Defences of the United Kingdom, Military Ports, and Coaling Stations. From June, 1883, to December, 1888, adviser to the Board of Trade in electrical matters connected with the Electric Lighting Acts. Was connected with the development of the present apparatus and electrical and mechanical processes employed in submarine mining, and with the compilation of the Army instructional books and methods on electricity and submarine mining since 1870. Distinguished as an electrical engineer. It may be said that the present satisfactory state of defensive torpedo warfare in this country is very largely due to his ability and energy.—Joseph Larmor, M.A., D.Sc. Fellow of St. John's College, Cambridge. University and College Lecturer in Mathematics. Senior Wrangler, 1880. Formerly Professor of Mathematics Queen's College, Galway. Fellow of the Royal University of Ireland. Examiner in Mathematics at the University of London. Author of the following Papers:—"Application of Generalised Space Co-ordinates, Potentials, and Isotropic Elasticity" (*Trans.* Camb. Phil. Soc., Vol. XIV.); "Least Action" (*Proc.* Lond. Math. Soc., Vol. XV.); "Flow of Electricity in Linear Conductors" (*ibid.*, Vol. XVI.); "Characteristics of an Asymmetric Optical Combination" (*ibid.*, Vol. XX.): "Electromagnetic Induction in Conducting Sheets and Solid Bodies" (*Phil. Mag.*, 1884); and other Papers on Pure and Applied Mathematics.

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ELECTROMAGNETIC THEORY.—XXVIII.

BY OLIVER HEAVISIDE.

(*Continued from page 598, Vol. XXVIII.*)

§ 133. The last equation brings us to the theory of potentials. There are several senses in which the word potential has been employed, to enumerate which would be valueless here. For our present purpose we may conveniently fix its meaning by defining the potential at A of a quantity ρ at B to be the quantity $\rho/4\pi r$, where r is the distance from B to A. This is the rational potential, of course.

When ρ is distributed throughout space, whether at points, or over surfaces, or throughout volumes, the potential at any point is the sum of the potentials of all the elements of ρ. That is,

$$\mathrm{P} = \text{pot}\,\rho = \Sigma\,\rho/4\pi r, \quad . \quad . \quad . \quad . \quad (195)$$

if P is the potential of ρ.

We may use the same definition when it is a vector that has to be potted, or potentialised. Thus, if $\mathbf{A}$ is the potential of $\mathbf{C}$, then

$$\mathbf{A} = \text{pot}\,\mathbf{C} = \Sigma\mathbf{C}/4\pi r. \quad . \quad . \quad . \quad . \quad (196)$$

The summation is now a vector summation. Also, pot means "potential," or "the potential of," and has no more to do with kettle than the trigonometrical sin has to do with the unmentionable one. It seems unnecessary to say so, but one cannot be too particular.

We may connect these potentials with ∇ as follows:—Given that

$$\text{div}\,\mathbf{F} = \rho, \quad . \quad . \quad . \quad . \quad . \quad (197)$$

that is to say, that the divergence of a vector $\mathbf{F}$ is ρ. The meaning of divergence has been explained more than once; both its intrinsic and its vectorial meaning. Now, if the vector $\mathbf{F}$ be explicitly given, it is clear that ρ is known definitely, since it is derived from $\mathbf{F}$ by differentiation, which should, perhaps, be regarded as a direct process, rather than inverse. But if it be ρ that is given, $\mathbf{F}$ is not immediately determinable, unless we subject $\mathbf{F}$ to limitations. For we may construct any number of different $\mathbf{F}$'s to satisfy (197). Let every elementary source ρ of $\mathbf{F}$ send out the quantity ρ of $\mathbf{F}$, according to my rational theory of sources already explained; that is, the unitarian system of *one* "line of force" to the *unit* "pole." Then, by the manner of construction, the resultant $\mathbf{F}$ will satisfy (197), and it will do so independently of the way we choose to let a source send out the flux it generates, whether equably or not.

But if it be done equally in all directions, so that $\rho/4\pi r^2$ is the intensity of the "force" at distance r from the point-source ρ, and $\mathbf{r}_1\rho/4\pi r^2$ the vector force to correspond, where $\mathbf{r}_1$ is a unit vector drawn from ρ towards the point under consideration, making the resultant $\mathbf{F}$ be

$$\mathbf{F} = \Sigma(\rho/4\pi r^2)\mathbf{r}_1, \quad . \quad . \quad . \quad . \quad . \quad (198)$$

we obtain a special solution of (197) which has a remarkable property, viz.,

$$\text{curl}\,\mathbf{F} = 0, \quad . \quad . \quad . \quad . \quad . \quad (199)$$

so that if $\mathbf{F}$ be electric force, the voltage in any circuit is zero. The meaning of curl, I may observe, has been explained more than once; both its intrinsic and its vectorial meaning. Those who seek can find. If they will not take the trouble to seek or to remember it is of no consequence to them. There are plenty of other things they may concern themselves about; perhaps more profitably.

The property (199) is visibly true in the case of a single source. It is therefore separately true for the fields of all the sources, and therefore, by summation, is true for the complete $\mathbf{F}$.

But (198) does not give the only vector which has no curl and a given divergence. For a constant vector (that is, constant throughout all space), has no curl and no divergence, unless we go to the very end of space to find the sources. Of course this constant solution has no relation to the sources ρ, and may be wholly ignored. If allowed, $\mathbf{F}$ would not vanish at an infinite distance from the sources. Remembering this, and excluding the constant solution, we may say that (198) is *the* solution of (197) and (199).

That there is no other solution may be proved analytically by Green's Theorem. But we do not really need any appeal to analysis of that kind, if the intrinsic meanings of divergence and curl are understood. For the admission that there could be a second solution, say, $\mathbf{F}+\mathbf{f}$, where $\mathbf{F}$ is the solution (198), would, by (197) and (199), imply that the vector $\mathbf{f}$ had no divergence, and also no curl anywhere. But the first of these conditions means that $\mathbf{f}$ is entirely circuital, if existent at all. The second denies that it is circuital. So $\mathbf{f}$ is non-existent.

Now observe that

$$-\nabla\,(1/4\pi r) = \mathbf{r}_1/4\pi r^2,$$

or the slope of the scalar $1/4\pi r$ is the vector with tensor $1/4\pi r^2$ and direction $\mathbf{r}_1$. It follows from this that

$$-\nabla\,\text{pot}\,\rho = \mathbf{F}, \quad . \quad . \quad . \quad . \quad . \quad (200)$$

when a single point-source is in question. Therefore, by summation, the same is true for any distribution of sources, or

$$\mathbf{F} = -\nabla\mathrm{P} = -\nabla\,\text{pot}\,\rho, \quad . \quad . \quad . \quad . \quad (201)$$

where P is the potential of ρ, as defined by (195), and $\mathbf{F}$ is as in (198). The slope of P, if by this we understand slope downwards, or vector rate of fastest decrease, is therefore the same vector as was constructed to solve (197) subject to (199).

Taking the divergence of (201), we have, by (197) and (194),

$$\rho = \text{div}\,\mathbf{F} = -\nabla^2\mathrm{P} = -\nabla^2\,\text{pot}\,\rho. \quad . \quad . \quad . \quad (202)$$

A solution of the characteristic equation of P, or

$$\nabla^2\mathrm{P} = -\rho, \quad . \quad . \quad . \quad . \quad . \quad (203)$$

is therefore (195), and it is *the* solution vanishing at an infinite distance from the sources.

If we start from (203), we should first use (194), and make it

$$\text{div}\,(-\nabla\mathrm{P}) = \rho. \quad . \quad . \quad . \quad . \quad . \quad (204)$$

Then, by (190), we see that $-\nabla\mathrm{P}$ has no curl, so that we have again the two equations (197), (199) to consider, as above.

The consideration of $\mathbf{F}$ rather than of P has many advantages for purposes of reasoning, as distinguished from calculation. This is true even in statical problems; for instance, when $\mathbf{F}$ is electrostatic force, and P the corresponding potential. When we proceed further, to kinetic problems, when $\mathbf{F}$ can no longer be wholly expressed as the slope of a potential, the utility of considering P at all, even for calculating purposes, becomes sometimes very questionable, and sometimes certainly useless and misleading.

From (202) we see that $-\nabla^{-2}$ and pot are reciprocal. In another form, $-\nabla^{-2}$ and pot are equivalent; or $(\text{pot})^{-1}$ and $-\nabla^2$ are equivalent. The property has only been proved for a scalar function, having a scalar potential. But since any vector $\mathbf{C}$ may be written $\mathbf{i}C_1+\mathbf{j}C_2+\mathbf{k}C_3$, and the property is true for the three scalars C_1, &c., it is also true for the vector $\mathbf{C}$. Thus, explicitly,

$$-\nabla^2\,\text{pot}\,\mathbf{C} = -\nabla^2\,\text{pot}\,(\mathbf{i}C_1+\mathbf{j}C_2+\mathbf{k}C_3)$$
$$= \mathbf{i}\,(-\nabla^2\,\text{pot}\,C_1)+\mathbf{j}\,(-\nabla^2\,\text{pot}\,C_2)+\mathbf{k}\,(-\nabla^2\,\text{pot}\,C_3),$$

because the reference vectors $\mathbf{i}$, &c., are constant vectors. So, if A_1 is the potential of C_1, A_2 of C_2, and A_3 of C_3, which makes $\mathbf{A}$ be the potential of $\mathbf{C}$, according to (196), we shall have

$$\mathbf{A} = \text{pot}\,\mathbf{C}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (205)$$
$$-\nabla^2\mathbf{A} = \mathbf{C}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (206)$$
$$-\nabla^2\,\text{pot}\,\mathbf{C} = \mathbf{C}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (207)$$

In short, the characteristic equation of the vector $\mathbf{A}$ merely unites, from the above point of view, the characteristics of the components, so that pot and $-\nabla^2$ are reciprocal when the operand is a vector, as well as when it is a scalar.

§ 134. But the above gives a very partial and imperfect view of the general theory of potentials. There are numerous other relations between a vector and its associated functions. For instance, if in (206), $\mathbf{A}$ be circuital, then the Laplacean ∇^2 may, by (193), be replaced by $-(\text{curl})^2$. That is, if $\mathbf{A}_1$ be circuital, and be the potential of $\mathbf{C}_1$, then,

$$\text{curl}^2\,\mathbf{A}_1 = \mathbf{C}_1, \quad . \quad . \quad . \quad . \quad (208)$$

or

$$\text{curl}^2\,\text{pot}\,\mathbf{C}_1 = \mathbf{C}_1. \quad . \quad . \quad . \quad . \quad (209)$$

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Here, then, we have replaced the scalar operation $-\nabla^2$ by the vector operation curl done twice. Of course, $\mathbf{C}_1$ is also circuital, as is proved by (189).

Again, let the $\mathbf{A}$ of (206) be polar, or wholly divergent, and be now called $\mathbf{A}_2$, the potential of $\mathbf{C}_2$; then, by (193), we shall have

$$-\nabla \operatorname{div} \mathbf{A}_2 = \mathbf{C}_2, \quad . \quad . \quad . \quad . \quad (210)$$

or

$$-\nabla \operatorname{div} \operatorname{pot} \mathbf{C}_2 = \mathbf{C}_2 \quad . \quad . \quad . \quad . \quad (211)$$

Here again we have replaced ∇^2 by a double operation, first div and then ∇. This is similar to the passage from (203) to (204), only done in the reverse manner. In (210), by (190), $\mathbf{C}_2$ is polar, because $\mathbf{A}_2$ is.

Conversely, we see that the potential of a circuital vector is also circuital, and that the potential of a polar vector is also polar.

Now $\mathbf{A}_1$ has no divergence, so it may be added on to the divergent $\mathbf{A}_2$ in (210) without affecting its truth. Thus, if $\mathbf{A} = \mathbf{A}_1 + \mathbf{A}_2$, we have

$$-\nabla \operatorname{div} \mathbf{A} = \mathbf{C}_2. \quad . \quad . \quad . \quad . \quad (212)$$

Similarly, $\mathbf{A}_2$ has no curl, so may be added to the $\mathbf{A}_1$ in (208), giving

$$\operatorname{curl}^2 \mathbf{A} = \mathbf{C}_1. \quad . \quad . \quad . \quad . \quad . \quad (213)$$

Here remember that $\mathbf{A}$ is the potential of $\mathbf{C}$ or $\mathbf{C}_1 + \mathbf{C}_2$.

These equations supply one way of effecting the division of a vector $\mathbf{A}$ of general type (having both curl and divergence) into two vectors, one of which, $\mathbf{A}_1$, is circuital, whilst the other $\mathbf{A}_2$ is polar. For $\mathbf{A}_2$ is the potential of $\mathbf{C}_2$, so, by (212),

$$-\operatorname{pot} \nabla \operatorname{div} \mathbf{A} = \mathbf{A}_2 \quad . \quad . \quad . \quad . \quad (214)$$

separates $\mathbf{A}_2$ from $\mathbf{A}$. Similarly, $\mathbf{A}_1$ is the potential of $\mathbf{C}_1$, so by (213),

$$\operatorname{pot} \operatorname{curl}^2 \mathbf{A} = \mathbf{A}_1 \quad . \quad . \quad . \quad . \quad (215)$$

separates $\mathbf{A}_1$ from $\mathbf{A}$, and therefore $\mathbf{A}_2$ from $\mathbf{A}$ by a different method. There are many other ways of splitting $\mathbf{A}$ into circuital and divergent parts. The one most easily understood, apart from the mathematics, is the following. Go over the whole field of $\mathbf{A}$ and measure its divergence. If we find that there is no divergence, then we do not need to go further, for we know that $\mathbf{A}$ is circuital already; that is, $\mathbf{A} = \mathbf{A}_1$, and $\mathbf{A}_2 = 0$. But should there be divergence, say B_2, so that

$$\operatorname{div} \mathbf{A} = \operatorname{div} \mathbf{A}_2 = \mathrm{B}_2, \quad . \quad . \quad . \quad . \quad (216)$$

then construct the flux $\mathbf{A}_2$ corresponding to the divergence B_2 according to the method already explained with respect to (197); thus,

$$\mathbf{A}_2 = \Sigma(\mathrm{B}_2/4\pi r^2)\mathbf{r}_1 = -\nabla \operatorname{pot} \mathrm{B}_2, \quad . \quad . \quad . \quad . \quad . \quad (217)$$

by (198) and (200). Knowing $\mathbf{A}_2$, we know $\mathbf{A}_1$, or $\mathbf{A} - \mathbf{A}_2$.

Or we might vary the process thus. First measure the curl of $\mathbf{A}$. This is the same as the curl of $\mathbf{A}_1$ because the curl of $\mathbf{A}_2$ is zero. Let, then,

$$\operatorname{curl} \mathbf{A} = \operatorname{curl} \mathbf{A}_1 = \mathbf{B}_1, \quad . \quad . \quad . \quad . \quad (218)$$

and construct the circuital solution of this equation; that is to say, regarding $\mathbf{B}_1$ as given, find $\mathbf{A}_1$. It is given by

$$\mathbf{A}_1 = \operatorname{curl} \operatorname{pot} \mathbf{B}_1. \quad . \quad . \quad . \quad . \quad (219)$$

For $\mathbf{A}_1$ as thus defined is evidently circuital, in the first place; and next, by taking the curl, we produce

$$\operatorname{curl} \mathbf{A}_1 = \operatorname{curl}^2 \operatorname{pot} \mathbf{B}_1 = \mathbf{B}_1, \quad . \quad . \quad . \quad (220)$$

which is the given datum. Here we use $\operatorname{curl}^2 \operatorname{pot} = 1$, because the operand is circuital, as in (209).

But instead of (219) we may write

$$\mathbf{A}_1 = \operatorname{pot} \operatorname{curl} \mathbf{B}_1, \quad . \quad . \quad . \quad . \quad (221)$$

showing an entirely different way of going from $\mathbf{B}_1$ to $\mathbf{A}_1$. For $\mathbf{A}_1$ as thus constructed is circuital; and, since $\operatorname{curl} \mathbf{B}_1 = \mathbf{C}_1$, (221) is the same as

$$\mathbf{A}_1 = \operatorname{pot} \mathbf{C}_1,$$

which was our definition of $\mathbf{A}_1$ in terms of $\mathbf{C}_1$.

Thus pot curl and curl pot are equivalent when the operand is circuital, as above. They are, however, also equivalent when the operand is general, or both circuital and divergent, because if any divergent vector be added to the $\mathbf{B}_1$ in the right members of (219) or (221), the operation of curl to which it is subjected renders its introduction inoperative. We therefore have

$$\operatorname{pot} \operatorname{curl} \mathbf{C} = \operatorname{curl} \operatorname{pot} \mathbf{C}, \quad . \quad . \quad . \quad . \quad (222)$$

where $\mathbf{C}$ is any vector. We have also the similar exchangeability,

$$\operatorname{pot} \operatorname{curl}^2 \mathbf{C} = \operatorname{curl}^2 \operatorname{pot} \mathbf{C}, \quad . \quad . \quad . \quad . \quad (223)$$

where $\mathbf{C}$ is any vector. For, either way, the result is the circuital part of $\mathbf{C}$, or $\mathbf{C}_1$.

These results, though puzzling at first from their variety, are yet capable of being brought under rapid mental control by bringing them together in a compact form. Thus, start with any circuital vector $\mathbf{A}_1$. Let $\mathbf{B}_1 = \operatorname{curl} \mathbf{A}_1$, $\mathbf{C}_1 = \operatorname{curl} \mathbf{B}_1$, $\mathbf{D}_1 = \operatorname{curl} \mathbf{C}_1$, &c. We have a series of vectors

$$\mathbf{A}_1, \quad \mathbf{B}_1, \quad \mathbf{C}_1, \quad \mathbf{D}_1, \quad \mathbf{E}_1, \quad . \quad . \quad .$$

which are all circuital, and any one of which is the curl of the preceding. We thus pass down the series one step at a time by means of the operation of curling; for example,

$$\mathbf{D}_1 = \operatorname{curl} \mathbf{C}_1. \quad . \quad . \quad . \quad . \quad . \quad . \quad (224)$$

If, however, we wish to go down two steps, we do not need to go first one step, as above, and then another, also as above; but can make a double step in one operation by means of the Laplacean ∇^2. Thus,

$$-\nabla^2 \mathbf{B}_1 = \mathbf{D}_1. \quad . \quad . \quad . \quad . \quad . \quad (225)$$

Now go the other way. If we wish to rise up two steps, we can do it in one operation by potting; thus,

$$\mathbf{B}_1 = \operatorname{pot} \mathbf{D}_1. \quad . \quad . \quad . \quad . \quad . \quad (226)$$

If we wish to go up only one step, we may do it by (224), (225), (226) combined; that is, either go down one step first, and then up two, as in

$$\mathbf{B}_1 = \operatorname{pot} \mathbf{D}_1 = \operatorname{pot} \operatorname{curl} \mathbf{C}_1; \quad . \quad . \quad . \quad (227)$$

or else, first go up two steps and down one; thus,

$$\mathbf{B}_1 = \operatorname{curl} \mathbf{A}_1 = \operatorname{curl} \operatorname{pot} \mathbf{C}_1. \quad . \quad . \quad . \quad (228)$$

There are other less important combinations. But if we wish to make one step up directly, without making use of the double step, we must do it by the Ampèrean formula, already used, whereby we pass direct from electric current to its magnetic force, which, in rational units, is (when applied to any pair of neighbours $\mathbf{C}$ and $\mathbf{D}$ in the above series),

$$\mathbf{C} = \Sigma(\mathbf{V}\mathbf{D}\mathbf{r}_1)/4\pi r^2, \quad . \quad . \quad . \quad . \quad (229)$$

where $\mathbf{r}_1$ is a unit vetor from the element $\mathbf{D}$ to the point at distance r therefrom, where $\mathbf{C}$ is reckoned. We have now a complete scheme, so far as the circuital vectors are concerned.

(To be continued.)

A MODEL OF THE ELECTRIC ORGAN OF THE RAIA TORPEDO.

In the course of some articles in *La Lumière Electrique*, entitled "The Generation of Electricity by Living Beings," M. d'Arsonval discusses the nature of the source of the electric supply in animals such as the *gymnotus electricus* and the *Raia Torpedo*. The electrical apparatus of the *gymnotus*, says M. d'Arsonval, is situated underneath the animal, the positive pole being at its head, the negative at its tail. In order to give violent shocks and stun its prey at the first blow, the *gymnotus* folds itself into a circle, and completes the electric circuit through the body of the doomed animal. At the Collège de France M. d'Arsonval possesses a *gymnotus* which can give high-pressure discharges sufficiently powerful to magnetise electro-magnets. The maximum pressure is more than 100 volts, and the maximum current is probably 2 amperes. In the case of the *gymnotus* the discharge is continuous and unidirectional. In the case of the *torpedo* it is not so. Some people, says M. d'Arsonval, liken these electrical organs to voltaic batteries or Leyden jars, but such analogies will not bear examination. If such were the case it would only be necessary to connect the poles for a discharge to take place. Now, it is erroneous to state that the *torpedo* invariably gives a shock when touched. If you

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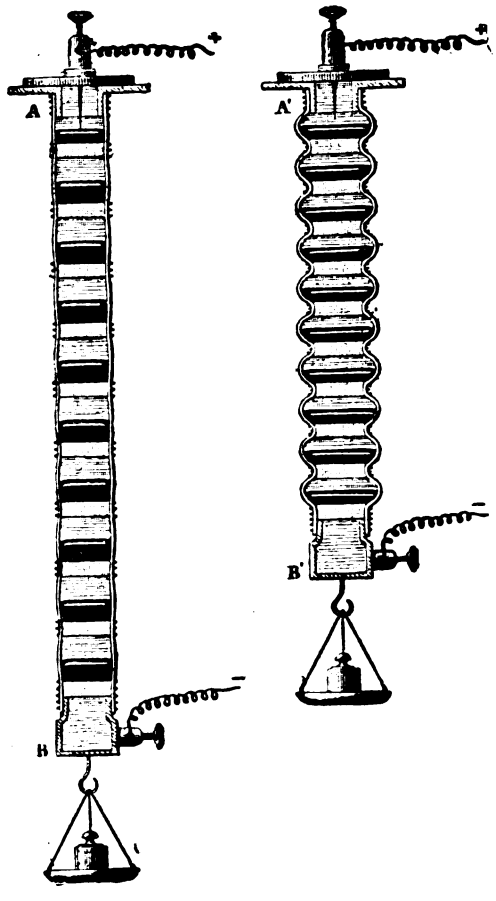
touch without irritating, nothing comes of it. Will governs the phenomenon. The electricity is not, so to speak, ready within the organs of electric fish; it is only generated when the animal wishes.

M. Lippmann has shown that an electric current can be generated in the following manner: Take two test tubes, place a layer of mercury in each, pour water on the top of the mercury, and connect the two vessels by a cotton wick dipping into the water. On inclining the tubes a current is produced in one direction, and on bringing them back to the vertical an inverse current is observable. The phenomenon is due to variations of capillarity.

These conditions are reproduced by protoplasmic matter. If we excite the protoplasm it alters shape and becomes a ball, and this deformation is accompanied by a negative variation, the surrounding liquid being positive. We thus have an electric current generated, bearing some proportion to the number of cellules.



It is easy, says M. d'Arsonval, to reproduce this experimentally. In the accompanying illustration a number of layers of mercury and water are shown superposed one on the top of the other in an india-rubber tube. If we stretch the tube we get an electric current. If we have several thousands of such cells, and if each gives an electromotive force of only one-third of a volt, a very high potential difference is soon obtained. Here we have the reason why these organs are voluntary organs, and only generate electric currents under the influence of the animal's will.

THE DISTRIBUTION AND MEASUREMENT OF ILLUMINATION.*

BY ALEX. P. TROTTER, B.A., ASSOC.M.INST.C.E.

This Paper was divided into three sections. The first dealt with geometrical principles, the second with photometers, and the third with the results of measurements made in the streets and public buildings in London.

When light falls upon a surface, that surface is said to be illuminated. Illumination consists of two factors—candle-power and distance.

* Abstract of Paper read before the Institution of Civil Engineers, May 10, 1892.

The carcel-meter was proposed in 1882 as a unit of illumination. Mr. Preece showed that this was equal to a standard candle at 12·7in., and proposed the name "Lux" for the English equivalent. The author has taken the candle-foot as a practical unit. The illumination of a horizontal plane at any point varies as the cube of the cosine of the angle of incidence of a ray of light falling on that point, when the candle-power and the height of the lamp are constant. Curves were given, showing this distribution graphically; illumination being represented as ordinates, and distances from the source of light as abscissæ.

The distribution of the total light on a surface varies as the solid angle subtended by that surface at the source of light. The usefulness of a white reflector depends on the solid angle which it subtends, and not upon its absolute dimensions. The resultant illumination, due to a number of lamps spaced at distances apart, equal to once, twice, three times, and six times their height from the ground, was shown by a number of curves. The distribution of the light of a continuous-current arc lamp is peculiar. For angles of incidence greater than 50deg. it varies as the fourth power of the cube of the cosine of the angle of incidence. Light falling in a more vertical direction is largely reduced by the shadow of the negative carbon.

The object of street lighting is twofold—to mark out the street with beacons, and to provide illumination. Illumination begins to be useful when it is comparable with moonlight. Moonlight in this country rarely exceeds one thirty-sixth of a candle-foot, that is, a candle at 6ft.; it is generally between one-sixtieth to one-hundredth of a candle-foot. The distribution of illumination in more general cases was treated geometrically; the variation of illumination due to the varying height of a lamp was discussed, and it was shown that there was no particular virtue in the angle of incidence, the tangent of which is $\sqrt{2}$.

Calculated contour curves of equal illumination, due to two lights at a distance apart equal to three times their height, and to three lights arranged in a triangle, at a distance apart equal to one and a-half times their height, were given, together with curves of illumination due to arc lights spaced in a similar manner. The use of diagrams to which the author gave the name of characteristic curves was explained. In several respects these resembled steam-engine diagrams. The co-ordinates were candle-power and area; the area of the diagram was a measure of total light, or power in an optical form. The maximum and minimum illuminations in any example could be seen at a glance, and the shape of the curve showed the quality or regularity of the distribution. Characteristics for a square and for a circular area illuminated by a single light, and for several arrangements of uniformly spaced lights, were given.

The second section on photometry alluded to the different attempts which have been made to supplant photometers by thermopiles, radiometers, and photographic methods. The complication of gas-testing apparatus was contrasted with the simple forms of true photometers, such as those of Bunsen, Rumford, and Foucault. A photometer was described, in which a shadow was thrown by a mirror upon a screen and a reflected beam of light was superposed upon the shadow; the whole screen was of a uniform tone when a balance was effected. In a direct-reading photometer, a rod was placed nearly in the plane of the two lights to be compared. Two shadows were thrown on a screen, and the position at which the two shadows were of the same tone could be read off on a scale. The illumination photometers of Weber and Mascart were briefly described. Mr. Preece's photometer of 1883 depended on the measurement of the current of a small glow lamp. The sixth power of the current was approximately proportional to the candle-power. The current was adjusted by resistances. The details of this photometer were discussed, and Captain Abney's method of rapid oscillations in photometric measurement was described. Various errors were introduced in this use of a Bunsen screen and by the colour of the electric lamp at low candle-power In a photometer designed by the author, in conjunction with Mr. Preece, in 1884, a glow lamp was made to approach or to recede from a Bunsen screen. The motion was given by a lever rolling on a cam in such a manner that the illumination could be read upon a uniformly divided scale. A number of modifications of this photometer were tried during the past winter, and resulted in the construction of an illumination photometer with which a large number of measurements had been made. Two glow lamps, ¾ and ½-c.p., were mounted in a long, blackened box. Either or both could be used at once. Four lithanode cells supplied the current. A reflecting screen covered with white paper threw the light upwards through a star-shaped hole in a horizontal screen of cardboard. The reflecting screen was mounted on hinges and could be wound up by a fine chain, finally folding quite out of the light. The chain was wound upon a cam, and a hand or pointer was mounted on the axis of this cam. The cam was so shaped that a nearly uniformly divided scale was obtained. The scale was graduated empirically. Readings were taken when the illumination of the horizontal cardboard screen appeared to be identical with the illumination of the movable reflecting screen, visible through

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the star-shaped hole. The range of this photometer is from 2·5 to 0·001 candle foot.

Measurements were made in the South Kensington Museum, in which illumination of about half a candle-foot up to 3½ candle-feet were recorded. In Cannon-street Station the minimum was 0·025 candle-foot, and the maximum 0·4 candle-foot. In Charing-cross Station the minimum was 0·05, and the maximum 0·5. Several sets of measurements were made in the City. The result of systematic measurement of part of Queen Victoria-street was given in contour lines of equal illumination. The maximum in an exceptional case was 1·1, ordinary maximum 0·3, minimum 0·025. Contour lines were constructed from a considerable number of measurements in Whitehall. The illumination in Great George-street, Westminster, was also measured. The maximum was 0·9, and the minimum 0·005. The author was assisted in the street measurements by Mr. W. Winny and by Messrs. J. Leggat, L. E. Pierce, and W. O. Wallace, students at Finsbury Technical College. Characteristic curves were drawn from these observations, and enabled the degree and the quality of the lighting to be compared. The Paper was accompanied by an Appendix, containing tables of the value of a bougie-meter in candle-power at different distances, values of $\cos.^3\theta$, and other powers of the cosine.

THE NATIONAL TELEPHONE COMPANY AND ITS SHEFFIELD SUBSCRIBERS.

A meeting of subscribers to the National Telephone Company in Sheffield was held on Monday last, at the Cutlers' Hall, to protest against the recent revised tariff. The Master Cutler (Mr. R. Belfitt) presided.

The CHAIRMAN stated that that morning he received the following letter from Mr. Gaine, the general manager of the National Telephone Company:—

"Gentlemen,—The attention of the Board of Directors of the National Telephone Company has been called to the meeting of subscribers to the Sheffield Telephone System, convened for the 9th inst., at which it is announced that you will preside, and it has been reported that the proposed new tariff has not met with general approval. On behalf of the Board, I beg, therefore, to put the views of this Company briefly before you. The Board considers that the telephone, as an important aid to business, has passed the experimental stage and become a necessity, and that the proper basis of the telephone tariff is to charge the consumer according to the use made by him of the telephone. This is the principle on which the charges for gas, electric light, &c., have always been made, and the charge for water has practically been arrived at by a somewhat similar means. It does not appear to the Board to be equitable that the subscriber who uses the telephone but three times a day on an average should pay as much as one who uses it 30 times a day. This principle has been recognised in several of the continental exchanges, where telephonic communication has been developed further than in this country; and it is with a view to dealing fairly with the subscribers that the Board put forward the new tariff as an experiment in what they believe is the true direction. If, however, the feeling of the subscribers in Sheffield is opposed to such a system, the Board desire to meet their views so far as they possibly can, having a proper regard to the commercial interest of the Company; and if I may, on behalf of the Board, be permitted to make a suggestion, it would be that a conference should take place between certain representatives of the subscribers and the Company. The Board are confident that consequent upon the amalgamation of the two telephone systems at present at work in Sheffield, they will within a very short time be able to supply a telephone service which will satisfy the subscribers; and the Directors are most anxious to acquire and maintain the subscribers' approbation and goodwill."

The CHAIRMAN said there could be no doubt as to the unanimity of the subscribers in objecting to the proposed tariff. The large attendance was a clear indication that they were not going to have any "fancy work."

Ald. W. H. BRITTAIN (President of the Chamber of Commerce) proposed—"That in the opinion of this meeting the revised tariff of rates which, on April 20, 1892, was submitted by the National Telephone Company, to the Sheffield subscribers, is excessive, and would prove most oppressive to the community of the district; and, further, that the scheme is an ill-considered one, and calls for united action on the part of subscribers." This was practically the same resolution as was passed by the Council of the Sheffield Chamber of Commerce last week. There were 100 gentlemen in that room who were masters of the situation. The proprietors of the rolling mills and tilts had only to decline to subscribe to the National Telephone Company.

Mr. R. COLVER seconded the resolution. There were, he said, something like 1,500 subscribers, and the number of messages sent per annum was 3,615,444, which gave an average of 2,410 for each subscriber. Assuming that each subscriber in future sent his full thousand messages a year, there would be 2,115,644 to be paid for at the rate of a penny each. These would produce £8,815. 3s. 8d. But many of the subscribers would not use the telephone a thousand times a year; whilst others would use it much more extensively; and as all the messages above one thousand would have to be paid for, he estimated that the Company would receive an income from this source alone of more than £11,000 a year. The amount obtained from the fixed charge of £7 a year from each subscriber was £10,500; so that from these two sources the Company would receive an income of £21,815 for an undertaking which he believed had cost them less than £50,000. He was not, he thought, committing a breach of confidence when he said that the proprietors of the whole of the rolling mills would cease to be connected with the Company's telephonic system if they did not withdraw their revised tariff.

Mr. PERCY HOOLE pointed out that the Company must have wires, and must also have posts. If people refused to allow this, the Company would come to grief.

Mr. F. R. BOOTH, the secretary to the Rolling Mills Association, mentioned that the members of that body had decided not to pay the proposed tariff, and, if necessary, to give up the Company's system altogether.

Mr. C. V. BUNTING stated that the Tilters and Forgers' Association had come to a decision similar to the one arrived at by the Rolling Mills Association.

Mr. A. T. WATSON said he had been in communication with the New Telephone Company.

Mr. F. E. SMITH said the subscribers had the whip-hand of the Company in every respect. He considered the town would be better served by the New Company. His opinion was that the Company was not to be trusted, and the sooner the subscribers had done with them the better.

The resolution was then put, and was carried unanimously, and a committee was elected.

The CHAIRMAN then stated that Mr. Gaine was present, and wished to address the meeting.

Mr. GAINE said this was the first time he had had the honour of addressing a Sheffield audience. He would at once and unreservedly say, on behalf of the Directors and himself, that it was their wish and absolute intention to have peace with their subscribers and to meet their wishes. The theory and idea of the Directors of the Company was to popularise the telephone as far as they could. He thought that those who used the telephone in a minor degree ought to pay less. Be that as it might, if it was not the view of subscribers and the people of Sheffield it certainly would not be forced down their throats. He could only add that when the committee just appointed met the Directors of his Company they would find that the Company intended to be reasonable and fair, and would meet the views and the wishes of their subscribers in Sheffield.

The proceedings then terminated.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, May 13th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "An Instrument for Drawing Parabolas." By R. Inwards, F.R.A.S. (2) "Some Electrical Instruments." By F. H. Nalder. (3) "An Instrument for Measuring Magnetic Fields." By E. Edser and H. Stansfield.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The New Star in Auriga." By Dr. William Huggins, F.R.S.

MONDAY, May 16th.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

8 p.m. Paper to be read: "The Art of Internal Illumination." By W. H. Preece, F.R.S.

TUESDAY, May 17th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Photography in the Colours of Nature." By Frederick E. Ives.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "The Distribution and Measurement of Illumination." By A. P. Trotter, Assoc. M.Inst.C.E. Paper to be read (time permitting): "The Measurement of High Temperatures." By Prof. W. C. Roberts-Austen, F.R.S.

WEDNESDAY, May 18th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Colour Blindness." By Capt. W. de W. Abney, F.R.S.

THURSDAY, May 19th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Chemistry of Gases." By Prof. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

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THE MEASUREMENT OF RAPID PERIODIC EFFECTS.

When it is desired to measure any quickly changing phenomena, like those which occur with alternating currents, ordinary instruments are far too sluggish for direct use. If the quantity to be measured is periodic, so that its value repeats itself after a given interval, it is always possible by means of a contact apparatus, making an instantaneous connection once during every period, to obtain a steady deflection with ordinary instruments. The quantity can thus be found at any particular instant, and by means of several experiments a curve can ultimately be obtained, showing the way in which it varies with the time. This method has been used in several valuable investigations on alternate currents, but it is not altogether satisfactory, as it takes a considerable time to make all the measurements needed. Another method which has been much resorted to for various purposes is that of instantaneous photography on a rapidly moving sensitised plate. This method is applicable whether the phenomenon under investigation is periodic or otherwise, but it requires special knowledge and skill. It has been used with much success in some beautiful researches by Lord RAYLEIGH and Prof. C. V. BOYS on the various forms assumed by the liquid particles in jets of water; and it was also resorted to by M. BLONDEL in some valuable work on the variations of current and voltage occurring in an alternating-current arc.

A more ambitious method than either of these is sometimes applicable when the phenomenon to be tested is periodic. It consists in making a spot of light trace out on a screen the actual curve which it is desired to find. The process

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is always some modification of the beautiful method first used by LISSAJOUS for studying the vibrations of tuning forks; and which has until lately been but rarely used outside physical laboratories. Some important applications of it are, however, now being made. The principle of the method is that a ray of light is reflected twice, in directions at right angles to one another and to the original path of the ray, by two rapidly moving mirrors, the motions of which are controlled by the values of the two quantities it is desired to compare. The ray so reflected is received upon a screen, and traces out a curve which gives the relation required. It will be remembered that, in a communication made some months back to the Physical Society, Professor PERRY described a new steam engine indicator, the working of which depended on this principle. By an ingenious contrivance one of the mirrors was dispensed with, the single mirror being subjected to two motions at right angles, the first being caused by the pressure of the steam, and the other by the motion of the piston. Dr. FRÖLICH about the same time described an important method for analysing alternate current curves. This also was an example of LISSAJOUS' method. One of the reflecting mirrors was rotated by the armature of the alternator, and the other was attached to the vibrating diaphragm of a telephone traversed by the alternating current under test. This apparatus aroused much interest at the Frankfort Exhibition, where it was exhibited by Messrs. SIEMENS and HALSKE.

Again in the April number of the *Philosophical Magazine* Mr. JOHN TROWBRIDGE describes an instrument which he calls a phasemeter, and which appears likely to prove useful in connection with the study of alternating currents. The method is merely that of LISSAJOUS, with two telephones replacing the tuning forks. Mirrors are attached to the diaphragms of the telephones, the axes of which are so placed that a ray of light reflected from both mirrors receives two deflections at right angles. The instrument lends itself very readily to the demonstration of the difference of phase which exists between the currents in branched circuits, and to the influence of different kinds of iron and steel in increasing the impedance of solenoids. The immediate object of Mr. TROWBRIDGE'S experiments was to seek evidence of wave propagation in the magnetism produced in a lengthy magnetic circuit by two magnetising coils traversed by alternating currents. Two test coils were used in connection with the telephones to investigate the magnetism in different parts of the circuit, and distinct evidence was obtained of differences in phase, though none was found of wave propagation. Further experiments were made which may be regarded as a practical demonstration of the truth of the results recently published in these columns by Profs. THOMSON and EWING, for by experimenting with a test coil imbedded in the interior of the core it was proved that the lines of force concentrated themselves at the surface of the iron. As the eddy currents produced in a solid core subjected to alternating magnetic force necessarily lag a quarter of a period behind the magnetism producing them, it might have been expected that the density of the lines in the inner part of the core would differ in phase from its value at the surface. An effect of this kind was looked for, but was not apparent, and this is the more remarkable as the iron core was no less than half an inch thick, and the eddy currents must, therefore, have been of considerable magnitude. Mr. TROWBRIDGE'S instrument may prove serviceable in studying the manner in which lines of force reverse under the influence of alternating currents. This is a subject about which as yet very little is known, and which is worthy of careful investigation.

REVIEWS.

Diaries of Sir Daniel Gooch, Bart. With an Introductory Notice by Sir THEODORE MARTIN, K.C.B. (London: Kegan Paul, Trench, Trübner, and Co.)

The late Sir Daniel Gooch was a striking instance of the attainment of honour, wealth, and power by one of humble origin. In his case it is the old story of thoroughness and devotion to the interest of his employers leading to success, or, as he himself puts it, "a determination not to be led into changes by the inducement of immediate advancement." Born at Bedlington, Northumberland, on August 24th, 1816, after a mischievous boyhood, during which, however, he secured a fair education, he entered the moulding department of the Tredegar Ironworks, afterwards passing into the pattern-makers' shop. In 1834 he began work at the Vulcan Foundry, near Warrington, under Mr. Robert Stephenson, the works being chiefly intended for building locomotives. In 1835 he went to the Dundee Foundry as draughtsman, and both while there and at Tredegar made experiments with the object of using the galvanic battery to generate power instead of steam. A year later young Gooch entered Mr. R. Stephenson's works at Newcastle, where he became impressed with the importance of the wider gauge, as a champion of which in later life he took a leading part in the Battle of the Gauges. In 1837 he went to Rochdale, and worked on the Manchester and Leeds Railway. In the same year Mr. Brunel appointed him in his 21st year locomotive engineer to the Great Western Railway, which post he held until 1864. About this time Mr. Gooch took a great interest in the "Great Western" steamship, which was built from Mr. Brunel's designs, and proved to be a successful ship, notwithstanding that Dr. Lardner *proved* she could not cross the Atlantic. At this time he designed two classes of engines for the Great Western Railway, which at the end of 28 years continued to do their work admirably, running at 60 miles per hour with good loads. In 1840 he took out a patent for steeling the surface of rails and tyres, but found so much trouble connected with it and the false position in which he was placed toward the Company that he never took out another patent, and further held a strong opinion as to Patent Law, which he looked upon as a curse to the country, and one which could not be worked with perfect honesty. "Patents are taken out for all kinds of absurd things by people with little or no practical knowledge of the work they undertake, and the really practical man in carrying out his work is met at all points by the claims of some patentee. The absence of a Patent Law would not retard invention. . . . the honour of being the originator of a real improvement would be sufficient stimulus." It is, however, not easy to see that this view would work satisfactorily, especially in the case of inventions upon which large sums have to be spent to bring them to perfection.

In 1843 the "Great Britain" steamship, built by Brunel, was launched. In 1858 the "Great Eastern" was launched, and in 1860 Mr. Gooch became a Director of the Company to which she belonged. In 1862 he was engaged in designing and building engines for the Metropolitan Railway. In 1864 another attempt was made to lay an Atlantic cable, and the Telegraph Construction and Maintenance Company was formed for the purchase of the works of Glass and Elliot and the Gutta Percha Company. Mr. Gooch became a director, and with Mr. (now Lord) Brassey, and Mr. Barber, purchased the "Great Eastern" from the bondholders, who had taken possession, for £25,000. The big ship was chartered for the purpose of laying the Atlantic cable, with which she sailed in July, 1865. The story of the failure of this expedition to complete the work is well known, as is also the successful laying of the 1866 cable, and the repair afterwards of that of 1865. While on the former expedition Mr. Gooch was elected M.P. for Cricklade, and on the accomplishment of trans-Atlantic telegraphy was created a baronet.

In 1869 the French Atlantic cable was laid under Sir Daniel Gooch's supervision, and later in the year the "Great Eastern" started to lay the Suez-Bombay cable. In 1872 Sir Daniel records that the "Great Western" shares had risen to 118, having been at 90 when he became chairman. After laying additional Atlantic cables in 1873 and 1874, the "Great

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Eastern" was dismantled and finally sold to be broken up. So that the greater part of Sir D. Gooch's honourable career was connected with the "Great Eastern" steamship and the Great Western Railway. After many weeks of suffering patiently borne, Sir Daniel died at Clewer on October 15, 1889.

The "Diaries" are very interesting reading, being written in a natural style, and dealing with many matters of general interest.

The Year Book of Science. Edited for 1891 by Prof. T. G. Bonney, D.Sc., L.L.D., F.R.S. (London: Cassell and Co.).

The voice of the scientist has long been heard in the land proclaiming, by no means *sotto voce*, that life is too short, and the working powers of the majority of men too limited to permit of them keeping pace with the ever-increasing flood of printed scientific matter, for we cannot call it literature, which has resulted, as might have been foreseen, from the spread of science and its consequent *vulgarisation*. "The Year Book of Science," we are told, "aims at alleviating to some extent this difficulty, by presenting a conspectus of the progress which has been annually made, divested, as far as may be, of technicalities. . . . The endeavour of its projectors and compilers has been to select those memoirs in each several department which appeared to be of somewhat exceptional interest, either by throwing light on special difficulties, or by being suggestive of further advances. . . . In this first attempt it has been thought better to err on the side of limitation."

The present volume, which numbers some five hundred pages, is divided into five parts, devoted respectively to Physics, Chemistry, Geology and Mineralogy, Biology (Animal) and Biology (Botanical), the various branches of these sciences being each in charge of one or more specialists. Dr. H. H. Hoffert is responsible for "Electricity," and Mr. P. L. Gray for "Magnetism." The forty odd pages occupied by the electrical events of 1891, in spite of several omissions, form a tolerably satisfactory survey of that period. The researches of Mr. A. P. Chattock on the phenomena occurring at the beginning of electric discharges from points; Prof. Nichols' investigations on the electric discharge between a ball and a point; Prof. Crookes' Paper on "Electrical Evaporation;" the investigations of M.M. Sarasin, De la Rive, Bjerknes, Blondlot, and others, in connection with Hertzian oscillations; M. Bouty's valuable contributions to our knowledge of the dielectric properties of mica; Prof. Mengarini's painstaking researches on alternate current electrolysis; and the year's work of Prof. J. J. Thomson, Prof. Elihu Thomson, and Nikola Tesla, are all summarised; and, what is of great importance, not only are the original sources of information quoted, but in many cases the names and dates of the most accessible reprints in this country are given as well. On the other hand, it is difficult, except on the ground of mere oversight, to understand why no reference has been made to the so-called "Ferranti Effect," the scientific aspect of which was so admirably set forth in the Paper which Dr. Fleming read last May before the Institution of Electrical Engineers, or to the great addition to the chemistry of the storage cell which is to be found in the Paper read before the Royal Society in June last by Prof. Armstrong and Mr. Robertson. Prof. Pickering's theory of dissociation into ions, Prof. Minchin's work on "photo-electricity," M. A. E. Kennelly's investigation into the relative effect of electro-magnetic and electrostatic induction on telephone circuits, and M. Mercadier's researches on the telephonic reproduction of speech, would also appear to be well within the scope of the volume.

The section on "Magnetism," although extremely brief, contains references to all the more important work of the past year, including that of Prof. Ewing, together with Mr. A. Hooper's remarkable experimental confirmation of Prof. Ewing's views; M. Decharme's Paper on "Superposed Longitudinal and Transverse Magnetisation," and M. Bachmetjew's interesting note on the "Influence of Magnetisation on the Thermo-electric Properties of Iron and Nickel."

As a first attempt "The Year Book of Science" for 1891 must be deemed a fair success, but many improvements and alterations will have to be made if its compilers propose that it should become a standard and reliable work of reference. The annual record of each science should, we think, be kept separate. Anyone who required a survey of the complete field could then purchase the entire set of volumes, while those who were only interested in one particular department would not be under the necessity of buying much which they did not want. In reality a scheme of this kind should be carried out on the co-operative principle and in a manner such that its scope is not "cabined, cribbed, confined" by financial considerations. The codification of science is not less necessary than the codification of the law, and if competent men with ample leisure could be found willing to undertake the humble but useful task of collecting, collating, and editing down the voluminous lucubrations of investigators, all over the world, we might hope to see the first fruits of the scientific labours of future generations made easily accessible, instead of, as at present, slowly but surely buried beneath a cataract of ink. If some such work could be brought into existence we might hope that careful abtracts of articles and Papers would be made for it, as a matter of course, by the authors themselves, much in the same way as publishers contribute a copy of every book they issue to the library of the British Museum. Gratitude has been defined as a lively sense of favours to come; in that acceptation of the word we ought perhaps to be grateful for "The Year Book of Science."

L'Année Electrique. By Ph. Delahaye (Huitième Année). (Paris: Baudry et Cie.).

This volume consists solely of excerpts from the French technical journals, and in consequence considerable prominence is given to primary batteries, arc lamps, electro-medical apparatus, and complicated telegraphic and telephonic devices. The extracts are in many cases taken entire, and little or no attempt has been made to present matters in a new light, or to apportion the space occupied by an article to the intrinsic importance of the subject it may happen to deal with. On the other hand, the contents of the book are conveniently grouped together under appropriate headings, and it will no doubt be of value to those who find it necessary to keep by them a sort of potted edition of the French electrical press.

Laxton's Price Book, 1892. (London: Kelly and Co.).

Like all modern books of reference, this well-known publication continues to steadily increase in bulk. The section devoted to electric lighting, although nearly doubled in length since last year, is still too scanty, even if we make allowance for the fact that the electrical industry, compared with carpentry, masonry, ironmongery, and gasfitting, is a very new one indeed. The eighteen pages allotted to electric lighting form but little more than three per cent. of the whole work, and nearly half of this space is taken up with the "Sun" Fire Office Rules, and with definitions of electrical terms. Instead of quoting the prices of two or three firms, to the exclusion of those of other houses, we would suggest that in future editions the electrical section would be more useful as a rough guide to the cost of electric lighting if a special *average* price list for each of the leading prices of apparatus were compiled from the price-lists of the leading makers.

On page 290 there is a rather startling printer's error, which results in our being told that the resistance of copper increases 21 per cent. for every degree Fahrenheit rise of temperature, instead of ·21 per cent. Again, among the "many eminent firms devoting great attention to producing the most efficient well-governed steam engine for electric lighting," an electrical engineer would certainly expect to see the name of Willans and Robinson.

To a regular electric light contractor or consulting electrical engineer the electrical section of this publication is not, in its present state, likely to be of much assistance, although no doubt to one not in the trade it would afford some clue as to cost.

"A Guide to Electric Lighting." By S. R. Bottone. (London Whittaker and Co.)

This is a cheap and concise addition to the long list of books brewed for consumption by amateurs and those extraordinary householders, who, because they propose to adopt electric lighting, are supposed to think it incumbent upon them to "read up all about it." The information given by the author is sufficiently accurate, lucid, and suitable for the purpose

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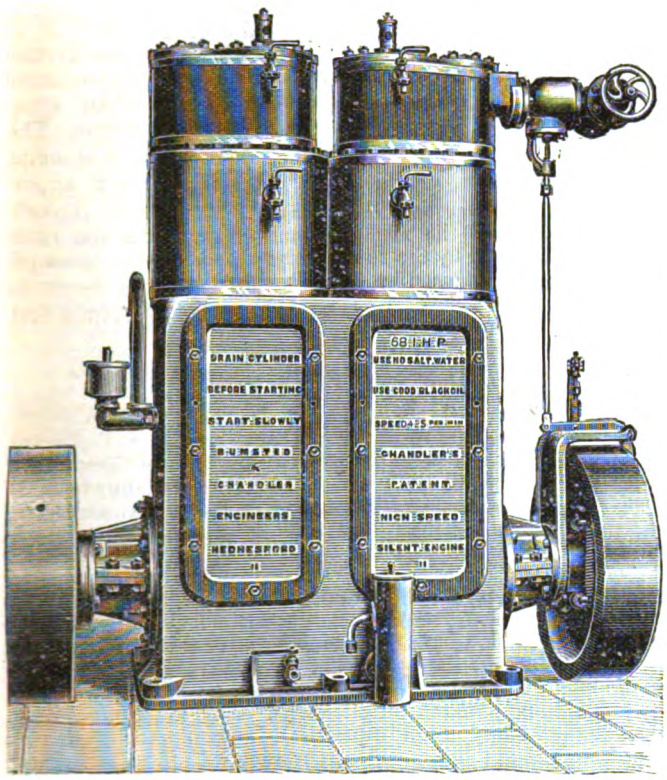
intended. We must, however, protest against the collection of arc lamps which has been gathered together in Chapter III.; it is too archaic, even for a book written for those who know nothing of the subject.

Problémes d'Electricité Pratique. By Dr. Filippo Cintolesi. Traduits de l'Italien par Felix Leconte. (Gand: Librairie Générale de Ad. Hoste).

This is a handy little collection of arithmetical exercises in electrical problems, such as are commonly set in schools and colleges; and although many of them are of "the natural-loadstone rubbed-amber" order, a practical turn is given to a large number.

BUMSTED AND CHANDLER'S HIGH-SPEED ENGINE.

The problem of building a really high-speed silent steam-engine has been solved by very few makers. Amongst the successful ones, the Chandler engine has held a place for many years; and we give herewith an illustration which, while it, unfortunately, gives hardly any information whatever about the engine, is at all events not more uninteresting than those



of other closed motors. The indicated horse-power of this engine is 68, the brake horse-power 61, and the speed 425 revolutions per minute. The diameter of the high-pressure cylinder is 8in., and of the low-pressure cylinder 11in. Both pistons are single acting, and have a stroke of 7in. The point of cut-off in the high-pressure cylinder is at half-stroke. Steam chest pressure is 120lb. Piston slide valves are used, and these can be taken out at the top of the cylinder by removing a small cover. The arrangements for cushioning are such that at 425 revolutions per minute the engine is absolutely silent when exhausting to a condenser. This is owing to a valve which causes a vacuum to act on the under side of the low-pressure piston only, thus the vacuum does not affect the compression or cushion.

Patent Statistics for France.—During 1891 the number of patents taken out in France amounted to 8,079, of which 90 related to telegraphic and telephonic apparatus, 199 to the generation of electricity, and 170 to the application of electricity.

THE PYKE AND HARRIS ALTERNATE-CURRENT DYNAMO.

This alternator is designed to work on the inductor principle, due primarily to Faraday. It embodies the following advantages:—The machine is remarkably solid, and for the space occupied is very powerful. The whole machine consists of two castings, iron stampings, and coils, cheap and simple to construct. Like all machines worked on the inductor principle, it has the advantage of no rotating wire or sliding electric contacts; both the field and armature coils being stationary. A further advantage in the Pyke and Harris alternator is, that in case of the failure of a coil there is a fuse arrangement attached to each connection, which melts before the current from the active coils passes into the defective one.

Fig. 1 is a vertical section, B representing the casting forming an annular space for the inducing coil, and enclosing the latter on three sides. D is the magnetising coil, which is surrounded with an iron casting on its inner and outer circumference, and on one face this casting extends beyond the edge of the coil. The gap is then closed, except at a narrow zone sufficient for the rotation of the inductors, by flat annular soft charcoal iron stampings, arranged so as to form a continuation of the field magnet, and provided with the necessary polar projections. The stampings are rigidly fixed to one another and to the field magnet. Fig. 2 (page 38) is an end view, the right half being shown with the inductors, and the left half without the inductors. The left half shows also some of the polar projections without the secondary coils.

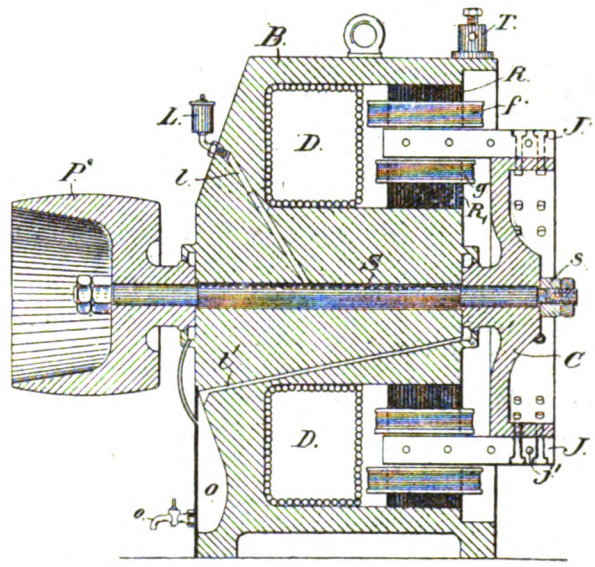


Fig. 1.—Pyke and Harris Inductor Alternator. Vertical Section.

The driving shaft S (Fig. 1) is supported by the casting, and carries at one end the inductors, which are bolted to the gunmetal disc C, while at the other end is fixed the driving pulley P. The shaft is lubricated by means of a longitudinal groove, which is supplied from a lubricator L through an oblique passage *l*.

The inductors are of approximately equal breadth to the distance from centre to centre of contiguous pole pieces. These inductors are subject to great magnetic strains, to resist which requires extreme rigidity. The material of which the inductors are composed requires to be built of the softest iron stampings, which are fixed by bolts of considerable thickness with strong metal supports. One important point in Messrs. Pyke and Harris's machine consists in the use of strengthening plates of steel between the stampings of soft iron which constitute the inductors. In the present machine the inductors are placed parallel to the axis of rotation of the carrier. The plates are separated from each other by thin sheets of paper, as is usual.

Electric currents are produced by revolving the magnetic inductors in proximity to the magnet, which is provided at

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both poles with polar projections, serving as cores for the conductors in which the current is to be induced. The object of the inductors is to complete the magnetic circuit alternately through each set of polar projections. An even number of polar projections are employed, and the revolving inductors are arranged so that in proportion as one pole is being demagnetised the magnetism of the other poles increases, and *vice versâ*, thus the total magnetic effect being always approximately constant. The induced-current conductor is so arranged that the polar projections which are being magnetised and those which are being demagnetised have a similar inducing action upon it, the magnetising of one set of polar projections thus increasing the effect produced on the same wire by the demagnetisation of the other set of polar projections. This invention may be used in machines for the production of single phase or multi-phase alternating currents or of continuous currents; the polar projections and the induced-current conductor being readily arranged for any desired disposition in the case of inductor machines, with the induced-current conductor placed on the polar projections.

The alternator shown at the *conversazione* of the Royal Society weighed about 7 cwt.; it was 15in. wide, 20in. long, and 21in. high over all. The output was 10,000 watts, and the magnetising current for full load 6 amperes at 50 volts. The clearance allowed between the inductors and the teeth of the stampings was $\frac{1}{16}$in. The casting was of mitis metal, guaranteed 60 per cent. permeability of wrought iron.

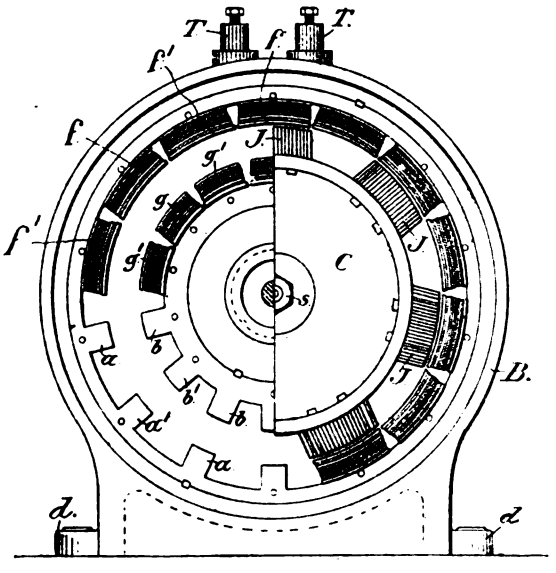

FIG. 2.—Pyke and Harris Inductor Alternator. End elevation and part section.

THE ST. JAMES AND PALL MALL COMPANY'S MAINS.

The following is a copy of a report presented to the Board of Trade by Major Cardew, R.E., on the subject of some defects which recently showed themselves on the mains of the St. James and Pall Mall Company:—

My attention was called to this damage,* and to two very similar cases of damage to water pipes, by Mr. Wilkins, clerk to the St. James's Vestry, on March 14th. It appeared that a lead water-pipe supplying the premises of Mr. Barker, pastry-cook, &c., whose shop is closely adjacent to that of Mr. Peat, had been eaten through twice within a few months. I examined a piece of pipe which had been thus damaged, and the appearance was suggestive of electric action. Mr. Barker's employés also averred that they had sustained electric shocks from touching the handle of a water tap on a boiler in metallic connection with the lead pipe. As the possibility of electric shocks was a very serious matter, I lost no time in having the main of the London Electric Supply Corporation exposed. This main terminates in a "dead end" nearly opposite Mr. Barker's shop, and I thought it possible that there might be serious leakage from this. But it turned out to be in very good order, and no shock whatever could be obtained from the outer casing of the main. The action on the water pipes, also, was much more likely to be occasioned by a main supplying continuous current. On March 29th I examined the gas meter on the invitation of the chief inspector, and its appearance was thoroughly in accordance with the theory of galvanic or electrolytic action as the cause of the damage. Two holes had been eaten through the back of the meter where it had been in contact with a damp wall, the rest of the meter showing no signs of corrosion. On March 30th I received an intimation from Mr. Wilkins that Mr. Barker's water service pipe had again failed. The ground was opened to remove the defective pipe, exposing a portion of the culvert of the St. James and Pall Mall Electric Light Company, which was laid just above the water pipe; and by means of a few tests with a galvanometer I satisfied myself that there was a steady difference of potential of about 6 volts between the iron culvert and the water pipe, the culvert being negatively charged as regards the pipe. This appeared to me sufficient to account for the mischief, and I notified the chief engineer of the St. James and Pall Mall Electric Light Company of the results of my test, and requested him to give me notice when the culvert was opened, in order that I might be present. Accordingly, I was informed that this would be done on the morning of April 5th. On account of some very important experiments with the new standard ampere balance, I was unable to inspect the culvert until the afternoon, by which time it had been partially opened. There was a good deal of water in it, and in some places this had evidently touched the positive main. There were also three lead-covered wires, which had been used as "pilot wires," lying loosely at the bottom of the culvert. Two of these wires had been fused, evidently by a considerable current, and a good deal of the insulation burned, as was evidenced by a sooty deposit on the main conductors and the culvert at the spot. This had occurred at two separate places, one being near Mr. Barker's shop and the other opposite Mr. Peat's. I have little doubt that a connection between the negative conductor and the iron of the culvert was effected by the fused and stripped ends of these pilot wires. This is confirmed by the following facts:—At the time of my inquiry last November into the explosions which occurred on this Company's system of mains, I found that the insulation of the negative side of their system of mains from earth was very defective. This fault was very persistent, but until the culvert was opened on April 5th it had not been localised and removed. Immediately, however, that this section of the main was disconnected to enable the culvert to be opened, the fault on the system disappeared, and the potential of the positive main from earth, which had been persistently about 190 volts, fell to about 110 volts. The explanation of the action is, I consider, this:—The negative main has been for some months in metallic connection with the culvert in one, or, perhaps, two places in this part of Piccadilly. If the insulation of the positive side had been perfect no electric action would have resulted. But this was not, and, in fact, could not be, the case. Consequently a leakage current was continually passing to earth from the negative at this place, and an equal current in the aggregate from the positive side through many small leaks. The lines of flow of current would be to absolute earth or zero potential in all directions. Any water pipes or gas pipes in the vicinity would be practically at zero potential throughout on account of their metallic connection with the whole mass of the water or gas mains of London. Consequently the lines of flow of current would, to a large extent, converge on any such pipes in the immediate vicinity, if only separated from the charged conduit by damp earth. In other words, there would, necessarily, be a flow of positive electricity from such pipes to the surrounding earth, and thence to the charged culvert. But the flow of positive electricity from a metal into a damp medium, or water, is always necessarily accompanied by the generation of oxygen at the surface of the metal—which, if oxidisable, is thereby corroded. This is the action which has destroyed the water pipes. The gas pipe happened to be laid in bitumen, and was thereby protected, but the gas meter, touching a damp wall within the influence of the leakage, was affected.

The state of the system of the St. James and Pall Mall Electric Supply Company, so far as it has been brought to my notice, may be briefly summed up as follows:—In September last two explosions occurred, due to accumulations of gas and water respectively, a faulty pilot wire causing the explosion of gas. On November 3rd I held an inquiry into these explosions, and, from information given me by the engineer to the Company, I proposed a test, which was carried out shortly afterwards, and revealed the existence of a very serious earth connection on the negative main. This earth connection the Company were unable to localise and remove, and it continued in existence until April 5th, when it was removed by disconnecting the section of main opposite Mr. Peat's, in Piccadilly. The local effect of this fault has been the damages

* Injury to a meter belonging to the Gas Light and Coke Company.

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now reported on; but it is certain that an equivalent oxidation of metal must have occurred on the positive main, or the house wires and apparatus connected with it, and it is not yet proved that this destruction has been so distributed as not to amount to material damage at any one point. On examination, it is again discovered that the fault originated in the pilot wires. In my report of inquiry I recommended that the Company should at once remove all pilot wires from the interior of their conduits. The Company stated, in answer to this, that they would, as far as possible, be removed; but that they found the wires had, in many cases, adhered firmly to the bottom of the culvert, and could, with difficulty, be removed. These wires, however, in the portion of culvert which was opened on April 5th, did not appear to be adherent to the culvert in any part.

The steps to be taken by the Board of Trade to provide against the recurrence of similar faults and their consequences will, I think, require very mature consideration; but I have no hesitation in recommending that the Company should, without further delay, remove every portion of the pilot wires from the culverts, and should test throughout their system of culverts for the existence of any appreciable difference of potential between the iron culverts and the gas and water pipes.

THE ELECTRIC RAILWAY SCHEMES IN PARLIAMENT.

JOINT COMMITTEE OF LORDS AND COMMONS.

The Joint Committee of the two Houses of Parliament appointed to consider the Bills concerning electric and cable railway schemes for the metropolis met for the first time on Monday, May 9th. The members of the Committee are Mr. Stansfeld (Chairman), the Earl of Lauderdale, the Earl of Strafford, Viscount Barrington, Mr. J. S. Gathorne-Hardy, Mr. Whitmore, Lord Kelvin, Mr. Story-Maskelyne, and Mr. T. H. Bolton; and all were present except the last-named three. The Committee had been instructed to "consider the best method of dealing with the electric and cable railway schemes proposed to be sanctioned within the limits of the metropolis by Bills introduced, or to be introduced, in the present Session, and to report their opinion as to whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and probable future traffic; as to whether any and which of the schemes propose satisfactory lines of route; as to the terms and conditions under which the subsoil should be appropriated; whether any, and, if any, what schemes should not be proceeded with during the present Session."

Mr. G. P. GOLDNEY, City Remembrancer, said, in answer to Mr. WHITMORE, that his attention had been called to the six electric and cable Railway Bills now before Parliament. Only four of them directly affected the City of London. First, there was the Central London Railway Bill. That was a modification of a scheme passed by Parliament last year. It was an electric railway, starting at Shepherd's Bush, and proceeding under the Uxbridge road, Oxford-street, Holborn, and Cheapside. According to last year's Act, it was to end at Cornhill; but the present Bill was to authorise a slight diversion between the Bank and the Mansion House, from whence the line would turn to the north-east, and go on to Liverpool-street, the terminus of the Great Eastern Railway, with which, however, it was not proposed to effect a physical junction. The next Bill in point of importance was the Waterloo and City Railway Bill, which proposed to make a line, speaking roughly, from the open space between the Mansion House and the Bank, along Queen Victoria-street, and under the Thames to the west of Blackfriars Bridge, and then by a curve to Waterloo Station. The City and South London Railway Bill was for the extension to Islington of the already working line from the Monument to Stockwell. Then there was the Great Northern and City Railway Bill, which authorised a line to be worked by electricity, but otherwise of a different character from the others, inasmuch as it was to have such a large bore or tunnel as to admit the ordinary railway rolling stock of the country. The other lines would be of the ordinary standard gauge, but would not have their tubes large enough to admit the locomotives and carriages ordinarily in use on English railways. There were two other schemes—the Hampstead and Charing Cross and the Baker-street and Waterloo—but as they did not affect the City he had not given them special attention. As to the four lines he had specially mentioned, the Central London proposed to have a large new station by the Mansion House and another at Liverpool-street; the Waterloo and City line would have its terminus near the Mansion House; and the City and South London Extension to Islington would have a station near London Bridge and one in Moorgate-street, within the City. He had watched generally the working of the South London line, and found that it was carrying an increasing number of passengers. The Corporation Committee had very carefully considered the routes of the proposed railways, and had had reports from their engineers on the subject; and, generally speaking, they considered the routes convenient. If the electric railways were to be treated simply as affording omnibus accommodation, the Waterloo and City Railway was certainly well adapted for the purpose, and the same might be said of the other lines. He would prefer as to engineering details that the Committee should hear the engineers themselves. It was desirable that no portion of the tunnels should be less than 10ft. below the undisturbed surface of the London clay. The Corporation Committee also thought it undesirable that any portion of the public way should be appropriated without some corresponding advantages being given to the public.

Mr. WHITMORE: What do you mean by advantages to the public?

WITNESS: The placing of stations conveniently for the public, the provision of proper accommodation, &c. Of course, in the City every inch of public way is so valuable that we do not want to give it up unless we get a *quid pro quo* in some way. Another point to which attention has been directed is the question of the liability of the companies for injury caused to property by the construction or maintenance of electric or other railways under the authority of Act of Parliament. There appears to be some doubt as to the state of the law. Some of the engineers, I know, are strongly of opinion there will be no vibration to affect the house property near their works; but the owners are afraid that there will be, and they are naturally anxious as to whether, in that case, they will be entitled to recover damages.

Lord THRING: It has been decided the other way, has it not?

WITNESS: Not absolutely, I think. A point of great importance to us, upon which we have had a long report from our engineer, is the proposed large railway station between the Mansion House, the Bank, and the Royal Exchange. That is included in the Central London Railway scheme. Their suggestion is that the whole of that space should be utilised for a large central station, and also for subways for foot passengers not using the railway, so that people might cross from east to west and south to north under cover, and also have access to the stations below. That is a gigantic scheme, and one well worthy of consideration; but, like other schemes of the sort, it can only be carried out at great expense, and, as far as the public is concerned, at very prolonged inconvenience, as the streets would have to be blocked, and great quantities of material would have to be carted away and brought there.

Mr. WHITMORE: Are there any other lines of route which you think would be very desirable?

WITNESS: No. The question of the best obtainable lines of route depends on a great many circumstances, one of them being the question of cost, as the railway companies can go under the streets much cheaper than under buildings. The routes proposed appear to be fairly good; I see no objection to them.

By Viscount BARRINGTON: I believe the engineering authorities are now satisfied that there is no danger to the foundations of St. Paul's Cathedral.

By Lord THRING: By omnibus traffic I mean generally passenger traffic—passengers without luggage.

Mr. J. H. GREATHEAD, in answer to the CHAIRMAN and other members of the Committee, said: I am joint engineer to all the proposed railways. Electricians will deal in detail with the question whether electricity can deal with the traffic that is likely to arise on any of these lines; but I myself have no doubt as to its power to do so. These lines, excepting the Great Northern and City, are all intended as omnibus lines. They are not intended to form junctions with existing railways or to take through trains from other lines. They form a set of lines dealing with the internal traffic of London.

The CHAIRMAN: Do you express the opinion that electricity would be capable of dealing with the traffic which might be expected to be conveyed on these lines, even supposing the lines were capable of taking up the ordinary rolling stock of the country?

WITNESS: Yes. The Great Northern and City Railway, although it is to be worked by electricity, will take trains through from the main line. On all the other lines except the Hampstead and Charing Cross, the electric power will run trains capable of seating about 336 passengers. These trains can be run, if necessary, every three minutes. I have made a calculation as to the numbers that could be carried on each of the lines. Taking the Waterloo and City line, for example, with a five minutes' service, they could carry 15,500,000 passengers per annum, or with a three minutes' service nearly 26,000,000—that is, assuming each train to be only one-third full. The diameter of the Great Northern and City Railway tubes will be 16ft., whilst the diameter of the tubes on the other lines will be 11½ft., and the outside breadth of each carriage about 9ft.

Viscount BARRINGTON: If there are to be no junctions uniformity of gauge and diameter would not be necessary?

WITNESS: No; but I think it would be desirable to have uniformity where convenient in case it should be required to make junctions in future, but I think it would not be desirable that the lines should be made capable of taking the ordinary existing rolling stock.

By Lord THRING: These railways will be capable of taking passengers' ordinary luggage if necessary.

Lord THRING: It is suggested that you will affect telephone wires and electric lighting wires.

WITNESS: That is a subject which has been carefully considered in connection with an overhead line. The question was referred to Lord Kelvin, who gave his opinion that the telegraph and telephone wires would not be affected. I may add that in connection with the City and South London, which is now working, we have had no complaints as to the telephone lines being interfered with, although there was at one time some slight disturbance in the earth currents, reaching as far as Greenwich and Tottenham. There is no reason why these lines should cause any disturbance of the telephone wires.

Lord THRING: Are you willing to accept a clause to the effect that you shall not be exempted from the common law of nuisance, so that if your generating stations do turn out to be a nuisance you shall not be able to plead the protection of your Act of Parliament?

WITNESS: I am afraid it would be a dangerous thing to accept such a clause, because it would open the way for all sorts of claims upon us; but I should say that any nuisance arising from our generating stations would be nothing at all comparable to that arising from the working of ordinary locomotive trains like those on the surburban lines. People soon get accustomed to the noise, and it ceases to be a nuisance.

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WITNESS then pointed out in detail the routes, &c., of the various proposed lines, viz., Waterloo to the Mansion House; Baker-street, *viâ* Regent's Park, Portland-place, Oxford-circus, Regent-street, Piccadilly-circus, Haymarket, Charing Cross, and Northumberland-avenue to Waterloo; Hampstead, *viâ* St. Pancras and Tottenham Court-road, to Charing Cross; London Bridge to Islington (extension of existing City and South London Railway); extension of authorised Central London Railway (Shepherd's Bush to Cornhill) to Liverpool-street; and Great Northern and City Railway, from a junction with the Great Northern near Drayton Park, to Finsbury-pavement.

In answer to Lord Thring, WITNESS said there would not be much nuisance caused by the carting of soil. The surface would be opened at the stations, and nowhere else, and the carts would be loaded on the sites of the stations. The quantity of material to be carried away would be very small as compared with what has to be removed in the case of an ordinary railway. The carting of material might cause some slight inconvenience to somebody whilst it was going on, but that would be only temporary; whilst the railway, when it was made, would be there for ever.

Replying to further questions, Mr. GREATHEAD said that if they could pass under buildings at no greater cost than under streets it would be desirable in some cases to do so, as they could thereby improve their curves; but it would not affect the question of gradients, as they were deep enough down to be independent of the surface gradients. As to generating stations on the Central London Railway, the only depôt would be at Shepherd's Bush, adjoining the coal yard of the North London Railway. The only generating station for the Waterloo and Baker-street Railway would be on the south side of Waterloo Station, and there also would probably be the generating station for the Waterloo and City Railway. The generating station of the City and South London Railway will be, as now, at Stockwell, and for the Great Northern and City it will be at the junction with the Great Northern at Drayton Park. The generating station for working the cable railway from Hampstead to Charing Cross will be near Chalk Farm Station. The ventilation on all these lines will be done by the trains themselves, which, being in separate tunnels, will drive the foul air out and draw fresh air in as they enter and leave the various stations. That has been practically tested on the City and South London line.

Mr. BIRCHAM, Parliamentary agent for the promoters, inquired what evidence the Committee proposed to take. He was prepared with such witnesses as Dr. Hopkins, Mr. Preece, Mr. Siemens, and others, as to the motive power to be used, and so on, if the Committee thought it desirable to hear them.

Mr. GATHORNE-HARDY suggested that they hardly wanted evidence as to the sufficiency of electricity as a motive power.

The CHAIRMAN (after consultation with his colleagues): One scientific witness will be sufficient.

The Committee then adjourned till Thursday.

At the meeting of the London County Council on Tuesday last the Parliamentary Committee reported that the Council's Committee proposed to submit to the Joint Committee the following propositions, among others, as indicating the position which the Council would take in the coming inquiry:—"(1) That the size of the tunnels of the lines should be sufficient to allow in the future of an interchange of traffic with existing railway lines; (2) that, subject to the other conditions, and to any geological or other unforeseen difficulties which may be met with, underground lines should not follow the line of existing streets, but should go from point to point, the depth below the surface being such as to avoid injury or inconvenience to buildings in the line of the railway; (3) that the companies should only be allowed to acquire the right of forming the tunnels without acquiring any absolute freehold in the soil, paying compensation for actual damage only." The Committee were of opinion that the traffic capable of being accommodated by a railway of the class proposed between the north and south of London was not of so large an extent as to justify more than one railway.

Mr. SAUNDERS moved as an amendment, "That the suggestion that only one such line should be constructed between north and south London be omitted, and that evidence be placed before the Joint Committee showing the importance of continuing into the country electric and cable lines which may pass under London in order to relieve the congestion of population and encourage building in the suburbs, and that, subject to the above, the course taken of the Parliamentary Committee be approved."

The amendment was agreed to, and the report of the committee as amended adopted

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 29, 1892.

The Chicago Exhibition Lighting.—What is undoubtedly the largest lighting contract ever let in this country has brought out very sharply the intentions of the General Electric Company. This Company, as your readers are aware, is made up of the Thomson-Houston and Edison Companies. The contract referred to is that of lighting the grounds and buildings of the World's Columbia Exposition at Chicago. As the matter stands now the contract has been let to the General Electric Company at the rate of $5.95 per light, or a total of $353,000. The first bid of the Company amounted to a total of $1,700,000, the reduced bid being brought about by the opposition of the Westinghouse Company, which put in a bid of $5.49 a lamp. It is said that Mr. Westinghouse still entertains hopes of getting the contract, and that he has offered to furnish bonds for $500,000 to do the work and to make a cash deposit of $50,000 to bind him to do it $50,000 cheaper than the General Electric Company. He is in New York to-day on business connected with this contract. The circulation of the reports concerning this action of the combined companies has brought out considerable unfavourable comment from the daily press. The *New York Herald*, for instance, begins an article in this morning's issue by saying that "it only remains for some enterprising syndicate to obtain control of all the air and water in the United States to put all its citizens completely in the corporate grasp." So much attention has been directed towards the Westinghouse interests by this action of the combination that the Westinghouse stock has almost doubled its value in the last two weeks.

The Allotment of Space in the Electrical Building.—The allotment of space in the Electrical Building in the World's Fair has just been made by Chief Barrett, and is distributed as follows among the foreign countries:—England, 20,000 sq. ft.; France, 16,000; Germany, 20,000; Austria, 1,100; Switzerland, 1,100; Belgium, 1,100; Mexico, 500; Spain, 500; Italy, 500; Russia, 500; Holland, 440; Denmark, 440; Norway, 440; Sweden, 440. The entire electrical building covers 245,000 sq. ft., being 700 × 350ft. The space allotted to the German and English exhibits is in each case 20,000 sq. ft., about 7,000ft. of this space is in each case on the floor. It is said in the German exhibit there will be at least one 1,000 H.P. motor and one 1,500 H.P. generator.

The Edison Filament Case.—The case of the Edison Electric Light Company, *v.* the United States Electric Light Company, well known as the Edison filament case, which was called in the Circuit Court of Appeals in this City last Monday, has continued before the Court through the whole week, and it is said that there is some hope of finishing the argument to-morrow. This is the first case upon the docket of this new Court, and in presenting the case the Court room has almost been turned into an electrical laboratory, and counsel on both sides have gone into the details of the subject so fully that the arguments partook very largely of the character of elementary lectures on electricity. Although the case may be closed this week, it is not likely that the opinion of the Court will be handed in inside of a month.

The Commercial Cable Company.—The annual report of the Commercial Cable Company was filed in the County Clerk's office in this city to-day. On January 1st last the Company had issued $7,716,000 of its authorised capital stock of $10,000,000, and its debts do not exceed $2,000,000, its assets are declared to be at least $10,000,000. The report is signed by John W. Mackay, A. B. Chandler and others, for the Directors. Among the many stockholders may be mentioned Jas. Gordon Bennett, Blake Bros. and Co., Sir Adolphe Caron, K.C., Earl of Leicester, H.R.H. the Duke of Connaught Lieut.-General Sir Peter Lumsden, and Sir Donald Stewart.

The Amalgamation of the Edison and Thomson-Houston Companies.—It is reported that June 1st is the date set for the actual amalgamation of the Thomson-Houston and Edison Companies. At present they are controlled by two individual Boards of Directors and two separate sets of officers; but it is announced that on that date a single set of officers and a new Board of Directors will take charge of the affairs of the Consolidated Company, and that either Mr. Coffin or Mr. Twombley will be the president.

British Association Meeting in Edinburgh.—One of the evening lectures to the British Association at the meeting which is to be held in Edinburgh in August of this year is to be delivered by Prof. J. A. Ewing; and the Saturday evening lecture to artisans will be delivered by Prof. C. Vernon-Boys.

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CORRESPONDENCE.

"THE KELVIN."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your to-day's number I see notices and tests of the name "kelvin" proposed for the "Board of Trade unit."

The Board of Trade had kindly wished to adopt this name, and had taken the necessary preliminary steps for introducing it into the Provisional Order for this year. But I have pointed out some reasons why this should not be done; and I am permitted to say that the Provisional Order will not introduce any new name.

I agree wholly with your short leading article on the subject except its first sentence, of which I can only say that I appreciate its kind reference to myself.

It seems to me that the difficulty which has been felt in the cumbrousness of the name "Board of Trade unit" will be obviated wholly and in the most simple manner by using "supply unit" to denote the particular unit defined by the Board of Trade for the reckoning of electric supply. Thus, supply meters, by whomsoever invented, will give their readings in supply units. Ordinary householders, who know nothing of ergs, of meg-ergs, of joules (though knowing the name and something of the work of Joule), of watt-hours (though all know James Watt), will naturally use the simple word "unit" in checking and paying their electric lighting accounts. In scientific statements such as those of page 3 of your to-day's number, in which you test the convenience of "kelvin," the double word "supply unit," with only four more letters, will perfectly distinguish the particular unit intended from all others.

I remain,
Yours faithfully,
6, Cadogan-place, S.W., May 6. KELVIN.

PACIFIC CABLE SCHEMES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Had it not been for the last paragraph of your article on the above enterprise, it is probable that the remaining part might have been left to your discerning readers to judge whether the arguments were weak or strong; but the spirit in which the finishing peroration has been writ is unworthy of the cause. The word "never" might have been used more faithfully than "later," as from the evident point of view of the writer of this article this proposed Pacific connection will never be required; but, Sir, the cry of "wolf" has met with so little success in view of the submergence of many new cables that it may be reasonably supposed that this will be once more ineffective.

I would ask you to allow me briefly to say that, granting the statement that a cable may be cut in time of war, it would occur to a thoughtful statesman that important use might be made of a quick communication before and up to the time of the declaration of war, when future movements up till the last moment might be transmitted, and also the fact of the declaration itself. It would be far better if an island or country were thus able to make everything ship-shape, rather than receive notice by the enemy's cruisers. Then the neutralisation of cables may yet be hoped for.

Following the prominent parts of your article I would say that there is little sentiment nowadays connected with cable schemes, excepting, perhaps, where monopolies still flourish. There cannot be any elsewhere by reason of the dividends which have to be scrambled for.

In the Pacific scheme it may be safely said there are no difficulties which may not be overcome, not even the raising of capital at a reasonable price. There is, however, I should imagine, a route amissing from your chart, by which the coast of Alaska might be cut out if need be, and Unimak need not be connected, although from your article I see no valid reason for missing the place. The great circle route need not be followed out in its entirety, as your dotted line shows, from Vancouver, and another route might be a profitable one; I should think much more so than any you have indicated. The ratio of telegraphing value so ably parodied by you might be received by a neutral with some distrust, as if there is so little value in Cathay why should there be such a race to bind John Chinaman to a rate agreement (vide Shanghai telegram, *Standard*, April 8, 1892)? There must be some considerable amount of traffic, or these many years hitherto unsuccessful wheedling would not have been thought worth the candle.

The English climate is very bad, and fogs sometimes exist on its coast, yet it would take some time to enumerate the number of cables coming to this country. They prevail also on the Atlantic as well as on the Alaskan coasts, about Halifax, N.S., for months at a time, yet there are three cables running into this port. There are four to Newfoundland, on whose banks there are occasional "mists," and, Sir, I have felt in one week's time no less than five severe volcanic shocks; and other places have been wrecked from the same cause, and still the cable messages go on their way rejoicing.

On looking at the map one is also distressed to find there is a cable from Naples to Palermo, which should certainly be taken up, or Vesuvius removed; but I would suggest that eruptions, &c., on shore are an element of safety seawards.

One word about the capital of £2,100,000. I do not think that this large sum would be necessary to connect Vancouver with Australia if the best route be taken, and it may reasonably be supposed that a profit might accrue at something less than the present Australian rate of from 9s. 5d. to 3s. 10d., and to Japan at from 10s. 8d. to 8s. per word.

In conclusion I think, Sir, that the profile you have shown may be left to experts. It would, however, suggest itself to an outsider that it might have been so far "jumped" up that the peaks may have been shown to serve as points for the planting of poles. A small profile is a very dangerous thing, and is not near so "wicked" looking as a greatly elongated one.

I hope you will yet be wishful of the rapid submergence of a connection which has so long been in embryo, and which is so necessary to manufacturing countries, such as Japan (vide *Japan Weekly Mail*) and our own.—Yours, &c., J. R.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I thank you for the opportunity of replying to "J. R." in this issue:—

It stands to reason that the connection most likely to obtain subsidies from the British, French, and the seven Australasian Governments is more likely to be adopted and profitable than "another route" which "might be a profitable one." Your correspondent's comparison of the English and Atlantic meteorological conditions with those of Alaska —"the most foggy and stormy region in the world"— requires no comment. Your critic is unhappy in selecting Vesuvius to poke fun at as a model of virtue. Although it has given itself out as a reformed character since the introduction of Christianity into Italy, it is not by any means guiltless of attempts on the lives of innocent submarine cables. No doubt this Mont de Piété has only been lying low in case "J. R." and his friends should remove it, together with Pompeii and the Colosseum, to the Chicago Exhibition. There is evidence to show that a direct line of subterranean volcanic communication exists between Vesuvius, Stromboli, Volcano, and Etna; and one cable alone, crossing this line, was four times interrupted in less than three years by submarine volcanic action, the ends recovered being charred. Other instances exist of 12 to 60 miles of cable being swallowed up in this way, and a cable across the Straits of Sunda disappeared entirely. Unfortunately for your correspondent, mere *badinage*, however clever, will, no more than sentiment, remove a foggy climate, heave up the bed of the Pacific, obviate submarine earthquakes and landslips, squeeze the continents of the world nearer together, raise money at a low rate of interest, internationalise submarine communication in time of war, cheapen the price of cables, nor increase telegraphic traffic.—Yours, &c.,

THE WRITER OF THE ARTICLE.

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ON THE RETARDATION DUE TO IRON PIPES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to the question put me by your correspondent "H. W. W." (*The Electrician*, May 6th, p. 17), the losses referred to in Mr. Preece's recent Paper will not occur with a three-wire alternate-current system of mains when the three wires are enclosed in one pipe. This follows from the fact that the algebraic sum of the currents in the three wires is zero at any section.—Yours, &c., J. A. EWING.

TRANSFORMER PREDETERMINATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the first article by Prof. Fleming on transformers, contained in your issue of April 22nd, there is, I think, a disagreement between equations (13) and (14), p. 655; (13) I think should be

$$\frac{44}{7}\frac{N}{l}I = B = \left(\frac{E\,10^8}{p\,S\,N}\right).$$

—Yours, &c., E. STANLEY SHOULTS.

Rowsley, North Finchley, May 4, 1892.

[Our Correspondent is correct. Equation (13), p. 655, was misprinted and escaped correction in proof.—ED. *E.*]

PHOTOGRAPHS OF RIFLE BULLETS, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the Note which you published in your last number on the bullet photographs which I have exhibited at the Royal Society *soirée* and elsewhere, you stated that the atmospheric phenomena had not before been observed. This is not the case. Mach and Salcher have obtained photographs showing the air waves and the vortices in the trail of the bullet, but their method did not admit of such clear definition, especially in the case of the atmospheric disturbances, as that which I have developed. At the South Kensington Museum and elsewhere I have explained Mach and Salcher's method, and shown some of their results, and in the short description of my exhibit printed in the programme of last Wednesday I referred to their experiments, but I was not able in the short time allowed to me to do more than state that they were the first to successfully take photographs of rifle bullets by means of the electric spark.—Yours, &c.,

C. V. BOYS.

MOLECULAR MOVEMENT IN A CONDUCTOR AND ALTERNATE CURRENTS OF HIGH FREQUENCY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—In the "Note on the Molecular Movement in a Conductor," published in your issue of the 22nd April, Prof. Dolbear says of molecular momentum, "If it be not longitudinal it may be transverse," and then supposes the molecules to be rotated, &c. May I ask, first, Is it necessary that the electric current is a rotation of the molecules? Second, Are there not electrical phenomena which cannot be accounted for if the axis of *movement* of the molecules be supposed to be longitudinal with the conductor?

Take the phenomenon which, of all others, requires molecular movement, viz., decomposition in a voltameter. The handing over of atoms, as first explained by Grotthuss in A.D. 1805, would seem to require, if there be such things as atoms, a continually repeated half rotation of the molecules, this action being each time accomplished by a freshly formed set of molecules throughout; because, after each half rotation the extreme molecules are split up, redistribution takes place, and again there is a half rotation, and so on.

Now, the magnetic field at right angles to the supposed "flow of current" would surely be due to the swing round of the molecules in a definite direction, if it be reasonable to suppose every molecule to possess in itself polarity. Then, if we make such a supposition, the electric currents in the conducting wire would also be due to a swing of molecules, which are all set alike, possessing polarity, being made to swing or oscillate upon an axis at right angles to their polarity, and at right angles to the length of the conductor. If the temperature of a body is due to a vortex motion of its molecules in all conceivable directions, this motion would give a certain polarity to the molecules; if this be a magnetic polarity, then the setting of the molecules all one way would give the magnetic field; the same would be the case if all oscillated one way, *i.e.*, if the axis of each vortex be oscillated. If the above be true, an alternation of current is an alternation of oscillation, and if the frequency of alternation be so increased that the alternations coincide with the oscillations of the axis of vortex motion, then the oscillation will become rotation, and at this point the electric current will be destroyed, for there will be a resultant vortex motion. Then can we, or can we not, suggest the following?

First. Intensity of current is the rate of oscillation of the axis of the vortex of each molecule upon an axis at right angles to the magnetic lines of force, and at right angles to the length of the conductor.

Second. Electric pressure is the force exerted in one swing of the axis of vortex motion of the molecules.—Yours, &c.,

Clapham, April 28, 1892. MORRIS C. TIARKS.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Gas Supply and Electric Lighting Committee of the Glasgow Corporation invite tenders for providing and erecting a switchboard, connections, &c, at the central station in Waterloo-street, Glasgow. Tenders have to be sent in to Sir J. D. Marwick, Town Clerk, City-chambers, George-square, Glasgow, on or before the 24th inst. Plans, &c, can be had of Prof. A. B. W. Kennedy, 19, Little Queen-street, Westminster, S.W. Further particulars will be found in our advertisement columns.

——— The Corporation of Oldham invite tenders for boilers, engines, dynamos, pipes, &c, for central lighting station. Tenders must be sent in to the Town Clerk not later than Thursday, the 19th inst. Specifications and drawings can be seen on application to Prof. A. B. W. Kennedy, 19, Little Queen-street, London, S.W., or to the Town Clerk, Oldham. Further particulars appear in our advertisement columns.

——— The Great Eastern Railway Company invite tenders for various stores, including telegraph materials, signal and point fittings, &c. Tenders are to be in by the 21st inst.

——— The General Post Office are inviting tenders for telegraph arms of good south of England oak (planed, bored, and chamfered). No time is given for the sending in of tenders, and all particulars may be had of Chas. E. Stuart, Controller of Stores, Telegraph-street, London, E.C.

TENDERS RECEIVED.—The following is a list of the tenders received for an installation of telephones and electric bells at the Hotel Metropole, Dublin:—

	£	s.	d.
Manchester and Liverpool Electric Company, Liverpool	855	0	0
Smeeton and Page, London	625	0	0
G. A. Nusbaum, London	600	0	0
R. S. Blackburn, Helsden Bridge	570	0	0
William Johnson and Co., Sheffield	528	0	0
W. A. Shaw and Co., Stockport	495	0	0
J. B. Saunders, Cardiff	460	0	0
Birmingham Telegraph Factory, Birmingham	449	0	0
Harold Clegg and Co., Manchester	430	0	0
Croggon and Co., London	420	0	0
Goodwin Electrical Company, Dublin	419	0	0
William Curtis and Sons, Dublin	400	0	0
Thomas Barton, Blackburn	373	0	0
Maunsell, Mercier, and Co., Manchester	345	0	0
J. Blackburn, Nottingham	315	0	0
E. L. Berry, Harrison and Co., London	300	0	0
Matthews, Ball, and Co., Leicester	293	0	0
McClellan and Co., London	291	10	0
Electrical Engineering Company of Ireland (Limited), Dublin (accepted)	280	0	0
D. and G. Graham, Glasgow	290	0	0
E. J. Dugdill and Co., Manchester	290	0	0
Gent and Co., Leicester	285	0	0
C. C. McCarthy, Belfast	265	0	0
Hills and Thomson (Limited), Liverpool	258	0	0
Jno. Pearce, Glasgow	249	10	0
Jas. Fletcher and Co., Burnley	235	15	0

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TENDERS RECEIVED.—Tenders have been received by the Bermondsey Vestry for laying down the necessary plant and fittings for supplying the electric light to the Town Hall, from Messrs. Joel and Co., at £1,068, and Messrs. Siemens Brothers and Co. (Limited), at £1,560; but the Vestry have as yet taken no action.

——— A special committee of the Chiswick Local Board are considering two tenders received for the electric lighting of the district.

APPOINTMENT VACANT. — The Corporation of Kingston-upon-Hull require a capable out-door foreman for their electric light works, at a salary of £2 a week. Applications, which must be in writing, and addressed to Mr. F. Harman Lewis, Borough Electrical Engineer, will not be received after Monday, 23rd inst. Further particulars appear in our advertisement columns.

SALE BY AUCTION.—Catalogues are now ready of the sale by public auction, by Messrs. Wheatley Kirk, Price, and Goulty, at 39, Queen street, London, E.C., on Tuesday and Wednesday next, 17th and 18th May. The catalogue includes a number of new, or nearly new, Brush and Willans engines, Babcock-Wilcox boilers, dynamos up to 45 units by the best makers, transformers, carbons, arc lamps, switches, instruments, &c., &c., comprising the estate of Nicholson and Jennings, and other owners. Included in the sale also are the patent rights in patents Nos. 17,479 of 1888, 4,703 and 9,917 of 1889, and a half share in No. 19,695 of 1889. The sale rooms are situate close to the Mansion House, and the sale commences each day at ten for eleven o'clock prompt.

DISSOLUTION OF PARTNERSHIP.—The partnership hitherto existing between Mr. J. Booth and Mr. L. Ellson, trading as Booth, Ellson, and Co., at Queen-street, Melbourne, and at Adelaide, has been dissolved by mutual consent as and from February 29th last. The business is being carried on by Mr. Ellson at the same addresses, under the style of Ellson and Co.

MUTUAL TELEPHONE COMPANY (LIMITED).—A resolution, passed at a meeting of this Company on April 8th, was confirmed on May 4th,—"That the Company be wound up, and that Edwin Guthrie, 71, King-street, Manchester, be liquidator." Claims must reach the liquidator by the 31st inst.

LEGAL.—In the High Court, on Saturday last, before Mr. Justice Kekewich, an application was made to restrain Messrs. J. R. Fawkner and H. Rogers, electrical engineers, from sub-letting a portion of the large premises recently taken by them in New Bridge-street, Blackfriars, to "General" Booth. The injunction was granted, with leave to serve notice of motion to-day (Friday).

MESSRS. W. SOUTTER AND SONS.—This firm are issuing some neat hanging designs of electric light fittings. Mr. J. J Smith, their London representative, has removed from 28, Holborn-viaduct, E.C., to 47, Holborn-viaduct, and 49, Farringdon-street, E.C. Mr. Smith also represents Messrs. A. and R. Cochran.

NEW RUSSIAN ELECTRICAL COMPANY.—A company has been formed, with headquarters at Moscow and known as the Société Electrotechnique Franco-Russe, to manufacture there all kinds of electrical machinery, and to undertake the construction of electrical tramways, central stations, telephone systems, &c.

ELECTRIC LIGHTING PROJECT.—Messrs. Siemens and Halske, of Berlin, says *Industries*, have sent in a project for the electric lighting of Warsaw in Poland.

MESSRS. G. E. BELLISS AND CO.—This firm have just issued their first complete catalogue of engines, boilers, machinery, &c. Messrs. Belliss and Co. are large suppliers to the British, Indian, and Colonial Governments, and to the Naval Departments of the chief foreign States. The catalogue contains illustrations of the well-known double-cylinder engine with dynamo of the "Defiance" type, the central-valve engine and dynamo of the "Crescent" type, and a number of others. The catalogue contains 60 large quarto pages, is well printed, neatly arranged, the illustrations throughout being admirable.

COUNTRY HOUSE LIGHTING.—Messrs. Ernest Scott and Mountain (Limited) have secured the contract for lighting Benmore House, the residence of Mr. H. J. Younger. A Priestman oil-engine of 18 B.H.P., with a Tyne shunt-wound dynamo of 12,000 watts, and accumulators capable of maintaining 80 lamps for 10 hours, will be used; the installation consists of from 180 to 200 lamps. Mr. W. A. Bryson, of Glasgow, is the superintending engineer.

ELECTRIC LAUNCHES.—Mr. W. S. Sargeant, of Chiswick, is fitting out for the season a number of electrically propelled launches, which include the "Glowworm" and the "Pilot," which are being built for Mr. Andrew Pears, the "Meteor" for Mr. Arthur Ash, and the "Florentia" for Mr. W. T. Crawshay.

CHICAGO EXHIBITION, 1893.—Notice is given in our advertisement columns that applications for space can only be received up to Saturday, the 21st inst., after which date applications will be filed in case any space should be hereafter available, but will not be included in the allotment.

ELECTRO-HARMONIC SOCIETY.—We have received a copy of this Society's balance-sheet, which, subject to audit, is to be presented at the annual general meeting to-day (Friday), at 28, Victoria-street, Westminster, S.W., at 4:30 p.m. The number of members of the Society is now 316. The accounts show a balance of surplus assets of £113.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C. from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

April 19, 1892.

7,361. W. L. SPENCE and B. DEAKIN. Manchester. Improvements in the distribution of electricity by alternate currents.

7,393. E. C. HESS. London. Improvements in telephone receivers.

7,404. S. H. SHORT. London. Improvements in or relating to electric railways and to dynamo machines and motors.

7,412. Sir C. S. FORBES, Bart. London. An improved battery element.

7,415. M. W. DEWEY. London. Improvements in and relating to electric railways.

April 20, 1892.

7,466. A. SHIELS. Glasgow. Improvements in electrical communication on railway trains.

7,487. W. A. S. BENSON. London. Improvements in electric switches.

7,492. H. OPPENHEIMER. London. Improvements in and connected with electric bells.

7,509. H. H. LAKE. London. Improvements in alternating-current electro-magnetic motors, and methods of operating the same. (W. Stanley, junior, and J. F. Kelly, United States.)

7,515. T. GRIFFITHS. London. Improvements in electric insulating composition.

April 21, 1892.

7,569. P. EVERITT. London. Improvements in apparatus for automatically operating electric lamp switches.

7,570. W. T. SUGG. London. Improvements in insulators for electric installations.

April 22, 1892.

7,629. C. E. MASTERMAN and WOODHOUSE and RAWSON UNITED (LIMITED). London. An electrically propelled canoe.

7,646. H. A. MAVOR, W. A. COULSON, S. MAVOR, and W. B. SAYERS. London. Improvements in electric switches or contact makers.

7,649. J. A. TIMMIS. London. A new or improved electric bell push or pull, &c., automatic indicator.

7,655. G. R. NUNN. Manchester. Improvements in electrical call and indicating apparatus.

April 23, 1892.

7,682. F. PRICE. Bristol. An improvement in electro-motors, applicable also to dynamo-electric machines.

7,690. J. A. KINGDON, London. Improvements in electro-motors.

7,717. W. L. WISE, London. Improvements in electric alarm apparatus, for use in connection with railways and vehicles, or trains travelling thereon. (D. Murquletz, Roumania.)

7,718. W. H. AKESTER, London. Improvements in, or connected with electric arc lamps.

April 26, 1892.

7,833. J. WALKER and J. HAMPSHIRE. Dewsbury. An electrical metronome or time-beater or regulator for musical and other purposes.

7,855. C. E. CHALLIS. London. Electric switches.

7,853. M. BINSWANGER. London. Improvements in the construction and insulation of electrical contact devices and like apparatus.

April 27, 1892.

7,915. A. W. ISENTHAL. London. Improvements in electric switches.

7,915. D. MARR. Manchester. Improvements in telephones.

7,961. G. W. PRICE. London. An improved electric circuit-closer.

April 28, 1892.

8,041. S. D. WILLIAMS. Newport. Improved telegraph codes and apparatus therefor.

8,046. H. C. L. HOLDEN, B. M. DRAKE, and J. M. GORHAM. Erith. Improvements in electrical measuring instruments of the Cardew type.

8,062. G. BRYANT. London. An improved machine for giving electric shocks automatically by the insertion of a coin.

8,064. W. A. G. BIRKIN. London. An improvement connected with thread-coating of electric wires.

April 29, 1892.

8,083. J. O. DALE. Birmingham. A means of electrically heating iron, steel, and other metals in the processes of rolling, drawing pressing, and stamping.

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8,090. J. W. WIGNALL, W. HIRST, and J. SMITH. Manchester. Improvements in the production and regulation of electric currents for lighting and other purposes and in apparatus connected therewith.

8,115. J. B. MILLAR. Glasgow. Improvements in and relating to posts or standards for carrying electric lights, wires, and the like.

8,119. W. J. WARD, junior. Newcastle-on-Tyne. Automatic make and break switch.

8,127. S. EVERSHED. London Improvements in electric telegraphs.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

5,711. THAME. Electrical seamless tubes, &c.

8,457. SPOKES. Electric arc lamps.

8,811. MENGARINI. Recording electric meters.

8,963. SISLING AND OTHERS. Wiring for electric lighting, &c.

9,227. SIEMENS BROS. AND CO. (Limited) (Siemens and Halske). Telephones.

9,249. ROWAN AND MCWHIRTER. Electro-magnets for holding tools, &c.

9,606. THOMPSON. (Stein). Telephone receivers.

9,628. FITZGERALD. Voltaic batteries.

9,629. FITZGERALD. Voltaic batteries.

9,637. ALABASTER AND GATEHOUSE. Electric cut-out.

9,689. JEANTY. Electric batteries.

9,803. ENGLEDUE. Galvanic batteries.

10,090. GRABAU. Electrolytic production of aluminium.

10,261. PIEPER. Electric motors.

10,612. SIEMENS BROS. AND CO. (Limited) (Siemens and Halske). Electrical transformers.

10,613. SIEMENS BROS. AND CO. (Limited) (Siemens and Halske). Rotary phase currents.

14,752. HEALD. Incandescence lamps.

16,451. THOMPSON. (Espian and another). Electric train signalling.

1892.

2,544. BOULT. (Still). Electrical motors.

3,970. MILLS. (Lundell). Dynamo-electric machines.

3,971. MILLS (Johnson). Electric propulsion of vehicles.

3,996. THOMPSON (Shults). Electric adhesive plaisters.

4,152. HERDMAN. Electro-therapeutic apparatus.

4,416. WESTON, W. H. and G. W. Electric switches.

4,610. PINKHAM. Electric gas lighting burners.

COMPANIES' MEETINGS & REPORTS.

Western and Brazilian Telegraph Company (Limited).

The twenty-third ordinary general meeting of this Company was held at Winchester House, Old Broad-street, yesterday, under the presidency of W. S. Andrews, Esq.

The SECRETARY (Mr. R. M. Cunningham) read the notice calling the meeting and the minutes of the last meeting, which were confirmed by the present meeting, and signed by the Chairman as correct.

The CHAIRMAN: Gentlemen, before proceeding with the ordinary business of the meeting I propose to make a few remarks. You will remember that at the last general meeting a vacancy had occurred at the Board, and that the Directors expressed their intention not to fill that vacancy for the present, giving their reasons for that intention. Subsequently, just before this meeting, we received an official intimation that a gentleman would be proposed for election as a Director. In issuing our report we stated this fact, and we also made pretty much the same remarks that we had already made at the previous general meeting. On behalf of this gentleman a circular was then sent round with proxies proposing his election for this meeting. We considered that circular. We thought that it was a very reasonable one, and we saw no reason why we should deal with the question any further. It seemed to us that we had relegated it pretty much to the shareholders to settle, and that the best course to pursue was to leave it there. Following upon this the proxies came in, and we found that there were a large number of proxies in favour of Mr. Coppen, the gentleman alluded to; but I must tell you that previously to this, when we considered the question whether we should reply to the circular at all, we came to the conclusion, informally, that should a substantial number of shareholders, such as would justify us in electing Mr. Coppen to the Board, support that gentleman, whatever our majority might be, we should elect him—in other words, we wanted to go with our proprietors as we always have done, and to act as reasonable men of business. We knew there were a large number of new shareholders. We thought that perhaps those gentlemen felt that, as they had become shareholders since this Board was elected, they were not in such close touch with the Board as they would like to be, and that this was a measure devised by them to bring them into closer touch with the Directors. As soon as the proxies were handed in we saw that they were far in excess of what we had in our minds fixed for a substantial number of shareholders; and, therefore, without waiting for any analysis of the proxies, we at once intimated to Mr. Ennis, on behalf of Mr. Coppen, and also to Mr. Coppen, that the Directors would propose at this meeting, from the chair, that Mr. Coppen should be elected. I may say that after we came to that conclusion, which we did under the impression that there was a considerable majority in our favour, we were told that that majority had dwindled considerably. It would be impossible to say what the majority is, but I may say that I think if there is a majority it is in favour of the gentleman at the other end of the room. I do not know what the shareholders may think of this, but many of them have probably come here to discuss this matter *pro* and *con.*; and in addressing the shareholders now, therefore, I would remind them that we are surrounded by certain opposition, which is always watchful and on the alert, and that as far as possible on this occasion we should strive not so much to discuss matters *pro* and *con.*—in fact, I would rather that there should be no speechifying at all—but that we should aim rather at unanimity. We should endeavour, as far as possible, to be unanimous on the point of Mr. Coppen's election. The Directors look upon it that they are entrusted with proxies for the general purposes of the Company—not at all to be used in any one direction. They are forwarded to us to use them, we think, for the benefit of the undertaking generally; and under the circumstances, looking at the number of shareholders who are in favour of Mr. Coppen's election, we think it is to the benefit of the Company that that gentleman should go on the Board. I do not know that I need trouble you further with this matter. What I have said seems to be pretty much in accord—if I may judge from the expression of feeling at the meeting—with the views of the shareholders; and, therefore, I will now propose to go on with the ordinary matter of the report and accounts. We shall take the re-election of the two retiring Directors after that matter is dealt with, and then I shall have the pleasure of proposing the appointment of Mr. Coppen. No doubt some gentleman who has been supporting Mr. Coppen will second the motion, but if not we shall be happy to second it from the Board, as well as to propose it. Now, coming to the more immediate business of the day, you will have seen, on the perusal of this report, that, to a certain extent, it is anomalous. There is a fair increase in the traffics; but although the volume of the traffic has grown, the money that it produces has been diminished. For the December half of 1890 our receipts amounted to £103,817, whereas in the past half-year they have been £92,345, or a decrease of £16,472; but the whole thing is explained beyond question when we see that for the half-year ended December, 1890, our loss on exchange was £731, while for the half-year ended December last our loss on exchange was £19,133. Now, that, of course, explains the whole thing; in other words, if the exchange this year had been as favourable as it was in the previous year we should not alone have had an increase in the work done, but an increase also in the money earned, and your position would have been practically the same as last year, and you would have had the same dividend. The difference in the dividend is owing exclusively to the loss on exchange, which is, as you all know, a matter absolutely beyond the control, as far as we can see, of any human being. Financiers themselves seem to differ as to what course should be taken with respect to the question of exchange. The full effect of our working does not end with our loss by exchange. When you do 17 per cent. more work it costs you something to do it. The staff, also, have been sickly abroad, and generally we have had anything but a favourable condition of things throughout the half-year. It is, therefore, very satisfactory to see that the total increase in our working expenses has only been £1,200 in spite of all that, and in spite of the increased work done; and, moreover, £400 of this increase arises from a totally distinct cause, which will not occur again. Analysing the expenses, you will find that the increases in Abstract A amount to £1,756 and the decreases to £831. The largest increase has been in connection with the staff at Brazil—in other words, the money has been spent where it has been earned; and I do not suppose that you would desire to alter that. This increase in the expenses of the staff has been caused by a day and night service, which was established, of course, in order to give the public the utmost accommodation. The line has continued open, in other words, and there has been this continuous service given. There are some small increases in the salaries which are paid in currency, which has not the same purchasing power, and therefore in these cases we have had to pay more. The sum of £406, out of this increase, has been on the land line at Rio and on the tug for repairs. Then, owing to the large number of messages handed in, stationery was required sooner, and we sent out a large supply, amounting to £305. Miscellaneous expenses have also increased £86, and altogether there has been the increase that I have mentioned of £1,756, the decreases aggregating £831. The net increase has therefore been £924. As regards the shipping, the "Norseman's" expenses amounted to £8,154; but although there was an increase of £602 in the cost of her coals there was a net decrease on her working of £249. I must, however, tell you that that is more apparent than real, because as a fact the ship was steaming for 97 days instead of 43, and you cannot work a ship for nearly double the time and do it for less money. The ship was employed in laying loops, and therefore £1,325 of her expenses were charged to reserve; there was thus a net increase on her working of £1,075, and that was for working the ship double the time that she worked in the December half of 1890. The expenses of the "Viking" show a reduction. She was at work 66 days instead of 26 days. We had medical expenses to bear, and we were working double the time with the two ships, and on the whole on the working of the two ships there was a small decrease of £68. Under Abstract C, which you always look at with a certain amount of interest—for it represents the London expenses—there is a small increase of £22, which is not worth explaining. It was caused mainly in the Clearing House accounts. We instituted a Clearing House some time back. We got that with the view of ensuring greater accuracy in the messages. All the messages are by

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this means compared, and any error is traced. The effect of that in the public mind is very great, for they see that our service is more accurate, and I believe it pays a hundredfold its expenses. There is a separate item of £402, which will not occur again, included in the expenses; that is on account of the arbitration, which is now finally disposed of. The outcome of it all is that there is a total increase of £1,204, including the £400 just named. For that we have done nearly 17 per cent. more work—the exact increase is 16·80 per cent.—we have worked under unfavourable conditions with respect to the public health and consequent difficulties in connection with the staff, as they had to be shifted and arranged, and all contingencies had to be met. With all these difficulties and all this increase of business we have unfortunately got £19,000 less money to deal with; but, as I have said, that has been caused by a matter beyond our control. The result is that we bring down a balance of £53,940. We put £15,000 to reserve and £6,293 to debenture redemption fund, and we recommend a dividend for the half-year at the rate of 4 per cent. per annum, carrying forward £4,486. Going next to a small matter, before I touch upon other subjects, you will remember that we discontinued the publication of the traffic returns. We thought that they were too tempting, for they were at that time enormously high. Unfortunately, they have now again gone down considerably, and we saw that the reason which actuated us in stopping their publication existed no longer; and therefore, as in the abstract, the Directors very much preferred to publish them, the publication was resumed. Now, as regards what you are most anxious to hear about, I expect, the competitions, you know that you have been fully informed with respect to the threatened coming of these competitions—I was going to say—almost *ad nauseam*, because they have had to be referred to at nearly every meeting that we have held. We were told at the last meeting that the French line—the French Company as we call it—had been opened, and that competition so far had not done us—I was going to say—any apparent injury. As far as we can trace the matter, that not altogether unsatisfactory state of things still continues. The French line does not appear to do us any great harm. The Central American Company was stopped during a great part of 1891 on account of the war with Chili, so we had not the competition of that line. It was re-established last September, when the war difficulties were over, and they have got to work again. On May 1 they reduced the rates. My impression is that they did that because they found they were not getting enough of the traffic. We followed that reduction to the Argentine and Uruguay. We cannot yet tell what the effect of that will be upon the homeward and also on the outward traffic. Again, at the last meeting, attention was drawn to another line which was threatened, and which we reported to you at the time. We were told that that cable was under construction, and that it would shortly sail. A shareholder, in fact, thought that it had sailed, but that was not the case then. It has, however, sailed since, and that line will probably be very speedily laid between Brazil, Pernambuco, and Senegambia. At Senegambia it joins up with the Spanish International line, which continues from Senegambia along the African coast, and lands finally on the Continent of Europe. It is quite impossible for us to forecast what the result of the opening of that line will be. We know that up to the present time a certain amount of traffic has gone by it which has been handed to us at St. Vincent, and we have obtained a proportion of the toll; but when the traffic goes all through by their own line we shall not get any share of it. We must, however, do the best we can. It must always be remembered that these cables are single lines, whereas we have duplicated our system, and have prepared for these competitions. The next point is that since we last met we have made a very satisfactory agreement with the Brazilian Submarine Company. Under our old agreement we were bound to duplicate our lines when the traffic actually called for duplication. We discussed the whole question in view of the competing lines which were being carried out, and we arrived at the conclusion that the prudent thing was to duplicate the only bit remaining unduplicated over the busy section at once, without waiting for a glut of messages over the one line existing, if that ever came. Matters were discussed, the outlay was pretty considerable, but in the end we came to an agreement on the point; and the Brazilian Submarine Company, upon the laying of this cable, will begin to pay us a fixed rate of £6,000 per annum for all time. We thought in your interest that that was a wise agreement to enter into, and it was wise also in the interest of the Brazilian Submarine Company for the protection of their very large revenues, and they were enlightened enough to see that. The effect of this, of course, will be what you can see by a glance at the map. It is the bit from Santos to Chuy, but you will observe that the completion of that gives us a duplicated system all the way from this country and Europe to Brazil and the countries I have just named, including the River Plate. The lines are duplicated from end to end, and the effect of that we anticipate will be very favourable. I did hope to-day that we might announce the completion of the laying of that line, but it will not be very long before that work is completed, and then we shall enter into possession of this £6,000 a year. Then, with respect to these new lines, I must tell you that we have applied the duplex arrangement to them, which practically, when you get traffic in both directions simultaneously, gives you the benefit of two lines out of the one line, so that instead of having two cables you will practically have three all the way the instant this is completed. That, of course, is as regards carrying capacity. Altogether, when this cable is completed, we shall have laid and paid for—without increasing the capital of the Company by one penny—2,235 miles of duplicated cable. I do not think that that is altogether a very bad performance. You have all of you taken an important part in that, because without your agreement that these large sums should be put to reserve, and so on, this work could not have been effected; and if any justification were needed it not only justifies the reserve, but shows the necessity of it. Over and above this we have come to another arrangement. As you are aware, the Central American Company secured the land running from Valparaiso in a very circuitous direction to Buenos Ayres, their object being to put prohibitive rates against us, so that we should not get any Chilian traffic, which we had previously got over the neutral line. That would have acted very unfavourably; but all the companies interested—the West Coast of America, which was working with us, the Brazilian Submarine Company, and our own Company—met and made arrangements under which the line, ceasing at present at Buenos Ayres, should be extended over the Chilian coast by a land line. That work is actively proceeding, and it will connect us up not merely with Valparaiso but with the number of ports up to Iquique, which you see marked on the map. We believe that this will have a very good effect. It will enable us to compete, and to compete under very favourable conditions, under the Chilian traffic. At all events, the companies interested in this communication have done their best. They have armed themselves, as they conceive, at every point, and they hoped to be enabled to give a good account of themselves. Of course, under all these circumstances, the reserve has been a very rapidly diminishing quantity. You know the old adage—that you cannot eat your cake and have it too; and in our case the reserve is swallowed up, and as against the reserve you have the duplicated lines—in other words, you have increased by two parts the one part which you had of revenue-earning capacity. You are now in a position, or you will be directly, to do three times the amount of work you formerly did—that is to say, if you could do one thousand last year you will be able to do three thousand when this work is completed; and that, I think, is a very satisfactory substitution for the 2½ per cent. interest which you used to get on the reserve. We must do our best to make up some of the reserve as soon as we can. On the whole the financial position of the Company is not unsatisfactory. You know that we have not issued the £50,000 of debentures that we had power to issue. We have not issued them because we always desired, if we possibly could, to prevent anything coming in between the shareholders. We do not want to put anything before you that is not already there, and we are going to do our best to avoid doing so. Including the £12,700 paid off last January, £35,801 of your debenture debt has been paid off. We have, besides, to the credit of the debenture capital fund £28,435. That is all in the right direction. The whole of it is not available—what you have paid off is not, but the other is an available asset. You also have unexpended capital of a little more than £8,000, besides the £43,912 in unsold securities. We calculate that the new cable will be pretty nearly covered by the assets we have, if it were necessary to apply them all in that direction. The cable was put out to tender, and the Telegraph Construction and Maintenance Company's tender was the lowest, and was therefore accepted, that is the Company which is laying the cable; and we know that it is a very good Company. We said in the report at our last meeting that we had removed the remainder of the old deep-sea cable where it was in the deep sea, which was for 200 to 300 miles. As soon as we had done that we thought we saw our way to a small ship. You are more like an omnibus cable—not a deep-sea cable; and, therefore, we may look upon it that your property is a very sound one, and you cannot have such losses on it as are made in the case of some deep-sea cables. We therefore determined to get a new ship, and we have succeeded in putting on the stocks a ship which is to steam at a very high rate of speed. She is to have good carrying capacity—pretty nearly as much as the "Norseman." She will be a steady, first-class ship, and will only be of 900 tons, instead of 1,368; therefore she will be more rapid and will be worked more handily, and we believe she will show much better results than the ship we have hitherto had. The "Norseman" is a very fine and steady ship, and a first-class vessel for working in deeper water; but we do not now want such a luxury, and we desire to work more economically. We shall have to pay for that ship, and she will cost a great deal of money—about £39,000. That was also by tender, and again the lowest tender was accepted. Our surveyors, of course, advised us that the firm tendering was first-class. We hope to get you these things, if we get satisfactory traffics, without issuing that £50,000 of debentures that I have mentioned; and at all events we shall do our utmost to achieve that object. Our success in the matter will depend very much on the state of trade. If trade and commerce are active and give us plenty of business we shall succeed. Another question which the shareholders take an interest in is the debenture re-organisation. The legal difficulties in connection with that matter have all been surmounted, and we were going into that matter with a view of carrying it out when we received a communication which compelled us to stay our hand. We believe, however, that the time has now come again when we can take the question; but we are told by those who know better than we do that it is not yet the time for proceeding with arrangements of this sort, and that it will be better to wait a bit and see how Brazilian and Argentine securities stand in the market. We have had the French competition for the full six months, and we have had that of the Central American Company for the last three months; and what has been the result? It comes to what I began by telling you—not a decrease in the number of the messages or of the words carried, for we have sent more messages and more words. I warned you, I think, at our last meeting that we did not expect to maintain those very large traffics that we had been having, as they were owing to exceptional causes; but I think we have been proved to be in the right—so far as this—that these new lines do not rush in at once, as was supposed by some, and carry off the very large bulk of our trade, for we have held our own. I think it proves a little more than that. I think it proves that the public does not care about change for the sake of change; and that, on the whole, the public does not appear to be dissatisfied with the work of the Western and Brazilian Company and the companies in connection with it, and to that extent we feel considerably encouraged. At the same time, of course, this new line that is laid to Senegambia will make the fourth line

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competing for the service of South America; and we cannot, therefore, lead you to expect that we are going to maintain all this traffic, though we shall do our best to do so. We have made large reductions from time to time. The new companies, notwithstanding, have made reductions. Why? Not in the interest of the public, but simply for the purpose of intimating that "Codlin is your friend, not Short." They want to get the traffic from our line, and I am pleased to see that the public is not to be hoodwinked quite so easily as had been anticipated. We cannot be behind. Where any reductions are made or other measures taken to get the traffic we must be prepared. We have prepared ourselves in this respect, that we are going to see what the value is of this great service, I may call it, which we have built up with these duplicate cables, these duplexed lines, these united administrations, with an experienced staff, and with, at the present time, this business; and we are going to see whether we cannot keep a good proportion of what we have got. If you look at the map, and trace the line, you will see that ours is the cord line—it is the direct line (as he proceeded to point out by reference to the map). It is 2,340 miles shorter to Buenos Ayres than the Central American line, 1,100 shorter to Valparaiso, and 223 shorter to Iquique. We have not buried our heads in the sand, but have kept our eyes pretty well open. We can give a more direct service, which means fewer transmissions, and that means fewer errors. It is not given to mortals to command success; but we have done our best, at all events, to deserve it. I do not think that there is anything more that I need trouble you with. If the dividend is passed it will be paid to-morrow. I now move:—

"That the report and accounts to December 31, 1891, be hereby approved and adopted, and that a dividend of 6s. a share, free of income tax, be declared, making, with the interim dividend paid in November, 4 per cent. for the year 1891."

Mr. C. W. EARLE seconded the motion.

Mr. ENNIS expressed great satisfaction at the course which had been taken by the Directors in regard to the election of Mr. Coppen as a Director. He regarded the Chairman's statement as very satisfactory; but he desired to call the attention of the Directors to the fact that a feeling of resentment existed in the minds of some of the shareholders in regard to the large amounts that have been written off and added to the reserve fund. For the rest, he congratulated the Chairman on his able statement.

Other SHAREHOLDERS addressed the meeting, some of whom expressed the opinion that smaller sums ought to have been carried to the reserve fund than had been done in the last two years.

The CHAIRMAN, in reply, stated that the £26,000 discount represented a charge on their revenue of £1,200 a year for all time, and therefore he thought that the Directors had acted wisely in paying it off. If they had not made the transfers to the reserve fund to which reference had been made it would have been impossible for them to have placed the Company in the strong position they had done by duplicating their lines, or it would have been necessary, in order to attain the same object, to have raised the £50,000 of debentures. Having replied to other points raised by the shareholders, he put the resolution, and it was carried unanimously.

The retiring Directors, Mr. C. W. Earle and Mr. D. H. Goodsall, having been re-elected, Mr. Coppen was unanimously appointed a Director; a further resolution being subsequently passed electing Messrs. Turquand, Youngs and Co. and Messrs. Deloitte, Dever, Griffiths and Co., auditors.

A cordial vote of thanks to the Chairman and Directors terminated the proceedings.

Chelsea Electricity Supply Company (Limited).

The ordinary general meeting of the shareholders in this Company took place yesterday, at the offices, Draycott-place, Sloane-square, under the presidency of Mr. J. Irving Courtenay.

The SECRETARY (Mr. S. J. Cluer) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the accounts before you represent the result of the second complete year of work; and you will, I think, agree with me that, considering the numerous obstacles a pioneer company is bound to encounter, the result is encouraging. The observations I have to make, and the comparisons I shall offer, will, I trust, confirm you in this opinion. No one who realises the difficulties of working up a business of this nature will be surprised at our not being able to pay a dividend as yet in addition to the debenture interest, but we are now in a fair way of earning some return on the ordinary share capital. The gross revenue is 67½ per cent. more than that for the preceding year, but the gross profits are more than three times as large as those of 1890. These profits have, as you will observe, been mainly used for the payment of debenture interest and the extinction of the suspense account. Now, although the improvement is great, we are convinced that a still greater improvement can be made. Much has already been done of which the benefit is scarcely felt in these accounts, as the alterations put in hand early in the year were not completed until December. The result of this was that during the greater part of last year the work was not only carried on under the old disadvantageous conditions, but the difficulty of supply was also enhanced by the alterations going on at the same time. Notwithstanding these adverse circumstances, the improvement in the last three months of the year as pointed out in the Directors' report, has been most marked, the current having been produced for the last quarter of 1891 at 33 per cent less than the average of the previous nine months. I am, however, happy to say that our resident engineer, Mr. Talbot, has successfully coped with all the difficulties of the situation, and has maintained an efficient supply. I need not go into the details of the capital expenditure, as the items are set forth fully in the balance sheet; but as an indication of the economy with which the capital has been used, I may mention that on December 31st last the expenditure for each lamp installed was only £2. 14s. 6d., and it is now less. During the last two years we have obtained an increase of about 20,000 lamps, the total number now standing at over 30,000. The lamp density in the area supplied by the Company is extremely good. At the end of 1891 there were 4,533 lamps installed for every mile of street in which the mains are laid, or 2·6 lamps per yard. The proportion of houses lighted in the streets in which mains are laid is one-quarter to one-third of the total number of houses. The plant is all in good working order, and the cost of maintenance has been moderate. The maintenance of generating plant is 3 per cent.; of buildings, just over ½ per cent.; of mains, 1½ per cent.; and of meters, 2½ per cent. on the capital expenditure. The maintenance of accumulators and accessories amounts to about 2½ per cent. of the capital expenditure on them; but I may remind you of what I have stated on a previous occasion, that the maintenance of accumulators includes the complete renewal of the plates, which are practically the only parts that wear out. The capacity of the present plant in ordinary weather is over 40,000 lamps; but as, in this part of London particularly, we have to take into account prolonged foggy weather, we have to allow a large margin, which reduces the safe capacity to, say, 33,200 lamps. By an expenditure, however, of about £1,600 this capacity could be increased to 36,200 lamps, and, by laying out a further sum of about £1,000, to 38,350 lamps. The introduction into our system of the continuous current transformer, which was initially arranged as part of the system by Mr. Frank King, and which was viewed by some authorities as somewhat in the nature of an experiment, has proved a permanent success. Apparatus of this class had not previously been used for the purposes of general electricity supply; and it is gratifying to note after two and a-half years' experience that they work most steadily and efficiently, and at a very low figure for maintenance. These are now made by the Electric Construction Corporation at Wolverhampton. We have not carried out the extension of our mains as contemplated when I last addressed you, and, consequently, our income has not been as large as was then estimated. I will now endeavour to give you an estimate of the revenue for this year. Taking only the additions to the lights which we now have in view within our present area, and calculating on the basis of the results of 1891, the gross revenue from current alone should amount to over £13,000, as against £9,681 for 1891, an increase of 34 per cent., without entering upon fresh territory. A profit of 2½d. per unit on this output would realise a sum sufficient to pay debenture interest on, say, £35,000 and a 4 per cent. dividend on the share capital. But we look for still better results. There is yet room for a substantial increase in the number of lamps where the mains are laid; new blocks of houses are rising, and we know of two estates in the neighbourhood of our mains which are about to be rebuilt. As I have before mentioned, nearly all new houses in this district are wired for the electric light. This bears upon a question which has been rather fully discussed—the reluctance to take the electric light among a number of people who do not care to incur the expense of having their houses wired, especially where the leases have only a short time to run. During the first quarter of the year we have obtained an increase of over 2,500 lamps. The revenue account for that quarter fully bears out the estimate I have just given you of the revenue for the current year. Our figures are based on a return per 8 c.p. lamp of 9s. per annum, an amount likely to be increased as more shops and trading premises come on the circuit. We are still giving our close attention to improvements in economy of working, and are continuously taking careful tests of results. The supply has already been acknowledged to be the best for the consumer, and it is second to none in steadiness and in quality; and we believe that a system of supply which is popular with the consumer must succeed in the end in giving satisfactory returns to the shareholders. He concluded by moving the adoption of the report and accounts. (The report will be found below.)

The DEPUTY-CHAIRMAN (Major-General Webber), in seconding the motion, said that owing to the nature of their district their returns must not be compared with those of other Companies supplying, for instance, St. James's or other parts of London, their lights coming on by only twenties and thirties at a time. The Chairman had said that the cost of the maintenance of the accumulators and their accessories had been only 2½ per cent. That was the case as regarded the past year; but he believed the average would be between 5 and 6 per cent. per annum, though that would be regarded as very moderate by all electrical engineers.

The CHAIRMAN, in answer to a question, said the meeting had been called at their offices and central station, where they had a suitable room for holding it; and they therefore thought it was unnecessary to go to the expense of meeting at a place in the City. In his remarks on the cost of maintenance of accumulators and their accessories he had referred to the past year only, and what he had said was precisely the case. Each year, of course, must take care of itself. What they would do with regard to the accumulators was not to estimate, and put down something for depreciation; but they would put in new plates and keep up the whole of the batteries each year as good as new, charging the cost to revenue. He then put the motion, and it was carried unanimously.

Resolutions were afterwards passed re-electing the retiring Directors, Major-General Webber and Mr. Nugent Daniell, and the auditors, Messrs. Cooper Bros. and Co.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

The following is the Directors' report, referred to above:—

The number of lamps installed on December 31, 1890, was 19,580, and on December 31, 1891, 27,500; the number installed at the present time is over 30,000. The gross revenue for the year is £10,172. 10s. 11d., as against £6,079. 12s. 5d. for 1890; and the gross profit for the past year £1,750. 11s. 4d., as against £542. 19s. 5d. for 1890,

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There has also been a decided reduction in the cost of producing the electricity, but, as the new chimney and the re-arrangement of the plant were not completed until the end of the year, the improvement was obtained only in the last quarter of the year, as the following figures will show. The coal, water, wages, and other running expenses, for the first nine months of the year amounted to 4·5 pence per unit sold, while for the last three months of the year they were only 3·0 pence per unit, or 37½ per cent. of the revenue, and there is every reason to believe that the improvement will continue. The management expenses, including rent, rates, and taxes, now represent 1·9 pence per unit sold, as against 3·0 pence per unit for 1890. The plant is all in good working order, and the mains are in first-rate condition and have given no trouble.

It has not been deemed advisable to make an issue of the Preference capital authorised by the shareholders at their last meeting, but the remaining £10,000 First Mortgage Debentures (part of an issue of £30,000) have been allotted. The money thus raised has been applied to the purchase of a site for an additional storage station, to additions and improvements to generating plant, to enlargements and extensions of mains, and to the building of a second chimney stack.

The Directors have to report the retirement from the post of Managing Director of Major-General Webber, C.B., who retains his seat on the Board as Deputy-Chairman. The retiring Directors are Major General Webber and Mr. Daniell, who, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Brothers and Co., also offer themselves for re-election.

Metropolitan Electric Supply Company (Limited).

The fifth ordinary general meeting of this Company was held on the 6th inst., at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. E. Cunliffe Owen, C.M.G.) having read the notice convening the meeting, the report was taken as read.

The CHAIRMAN: Gentlemen, the resolution that I have to propose is:—

"*That the report and accounts for the year ending December 31, 1891, presented to this meeting, be and are hereby approved and adopted.*"

The DEPUTY-CHAIRMAN (Mr. J. Denison Pender) seconded the motion.

The CHAIRMAN: Gentlemen, before I ask you to approve of that resolution I must give you a *resumé* of last year's work, and I beg that you will be rather indulgent with me to-day if my voice is not quite up to its usual mark. I am just recovering from a 16 days' confinement to my room from bronchitis, which is not a pleasant companion. I am not quite yet restored, though I only want to exercise a little care and prudence to enable me to perform my duties again as usual. When I had the pleasure of addressing you twelve months ago, I was able to report that our installations were all but completed, that our mains extended for 67 miles, and that we had 480 customers upon our books, and that, looking at the rate which we had calculated as being the proper rate that we might possibly earn, we saw the prospect of a good profit. Our position to-day is strengthened because we have now upwards of 1,000 customers upon our books, as against less than 500. Yet these customers are learning how to economise, and their consumption has not been in proportion to their increased number. But we have the satisfaction of having acquired experience, and, after all, our knowledge of electric lighting is based upon the experience we gather from day to day. But taking the consumption from our meters, the probability is that we shall be able to supply double or even more than double the number of lights we originally contemplated, so that all the expenses in connection with the production of the light have been, I may say, already incurred. And what we want now is more customers, rather than a larger rate of consumption from our present number. At all events, we are not depending upon that, but upon additional customers, because I would rather see our return based upon 5,000 customers than upon 2,000 customers. So that what we want now is to exercise patience and to push our business. We are a paying concern. It is growing every day, and while we are passing through very much the same phase that the gas and telegraph companies passed through—which latter companies have been passing under my own eye—I can see that there is a very satisfactory future before us, a satisfactory future to those who stand by the Company, and that there will also be a growing dividend. We did not contemplate Paddington in our first outlay, and therefore we have exceeded our capital expenditure by about £50,000. But in this case we have brought a very important district into our system, one which is likely to prove valuable in the future: but concerns like this must grow, and when we have secured for it an amount of custom, to take up all the light that we can produce, it will then turn out a very important installation indeed for the Company. I think it will be right to give you at the present moment an idea of the position of our Company as compared with the other companies. The lamp connections of the companies supplying the metropolis on January 1 last was, I am informed, as follows: London Electric, 36,000; Westminster, 62,000; Kensington and Knightsbridge, 38,000; Pall Mall and St. James's, 38,000; Chelsea, 28,000; House-to-House, 19,000; Notting Hill, 3,000; ourselves, 82,000, and we have since increased to 97,000. This morning, too, I find that in the last three weeks we have had applications for 5,103 lamps, which is the largest number we have ever obtained in the same time. You therefore see that we have got everything ready to supply the public, and we have the public almost clamouring to get our light. All that we want now is patience. Our stations have worked in a highly satisfactory manner; our mains have worked without hitch or breakdown; we have 122 miles of mains. There has been, unfortunately I think for electric lighting, a great deal of speculation—speculation not in money nor speculation as far as lighting is concerned, but speculation as to the best and cheapest mode of producing the light. We have not been in this speculation. We have built this system up so that it can be worked out solidly, and we have, I believe, the most complete and most economical system of electric lighting that exists in London at the present time. I have a great deal of sympathy with those who have spent their money to little or no purpose, and who have put too many eggs in one basket. That has not been our principle, quite the reverse; but still it would have been a grand step in electrical science if we could have recognised in some of these great ideas a financial success. I fear, however, that for the moment that is not the case, while what has been done in this respect reflects to a certain extent on the industry generally. I feel that as far as this Company is concerned we stand in a very strong position, for we have proved our system, and are now a paying concern. I suspect that for the moment disappointment has more or less affected the general body of the electric lighting companies' shareholders, but I may say that it has not shaken my belief in the future of the electric light; and as London and its suburban population is about the least well supplied any of the large cities in Europe, I consider that the field is only beginning to be occupied, that it is a very wide field, and when it is occupied it will be a very remunerative field indeed to those who have the courage to watch its progress with patience and stand by it. I shall not trouble you by going into the accounts. Our accounts are made up in accordance with the requirements of the Board of Trade. You have them before you. They speak for themselves. They have been superintended and approved by your auditors, Messrs. Deloitte, Dever, Griffiths and Co.; and if any gentleman wishes to put any questions to me on the subject, I shall be very pleased to answer him. As I have already said, we shall want a certain amount of additional capital, and we propose to raise that capital, as it will be only temporary, by the issue of £100,000 of debentures. We shall issue these debentures *pro ratâ* to the shareholders at par, and in amounts to meet the smallest investors. We think them very good indeed and that we are offering a plum to every investor in this Company, while we are giving a rate of interest which I consider rather a high rate under ordinary circumstances. Still, the amount is small, and I want to show the shareholders that we are in touch and in sympathy with them, and I wish to encourage them to go on by giving them a little better debenture than they could get elsewhere. In my opinion they could not get a better debenture than the one we are offering.

A SHAREHOLDER: What is the rate of interest?

The CHAIRMAN: Five per cent. I have stated before that when we get our present system into complete working order it will only be the beginning, I believe, of what will be a very extensive system indeed. We are not, however, going to run any risks. We are going to satisfy ourselves thoroughly: to nurse what we have got, which is good, and to nurse it to a point which will enable us to say that we will go ahead. In that case we shall require more money, and then we can deal with the whole of this £100,000 of debentures. At the outset, however, we do not expect to require more than £50,000, so as to enable us to complete our Paddington station. We shall then rest and watch our progress; and I hope when I meet you in another year I shall be able to show you that we have doubled the number of our customers again, as we have done in the past year. With these remarks I beg to move the adoption of the report and accounts. I have read the resolution, and it has been seconded by Mr. John Denison Pender.

A SHAREHOLDER inquired whether the residue of the ordinary shares offered last year had been taken up.

The CHAIRMAN replied in the affirmative, and expressed his readiness to answer any further questions. No shareholder, however, rising to address the meeting, he put the resolution, and declared it carried unanimously. Continuing, he proposed the next resolution, as follows:—

"*That a final dividend of 2s. per share on the whole of the ordinary shares of the Company be and the same is hereby declared, such dividend to be payable on May 14, 1892, to all holders on the Company's register on April 30, 1892.*"

Admiral Sir GEORGE H. RICHARDS, K.C.B., F.R.S., seconded the motion, which was carried unanimously.

The CHAIRMAN then proposed the re-election of the retiring Directors, Mr. J. Denison Pender, Admiral Sir George H. Richards, and Mr. John Benjamin Verity.

Sir JAMES ANDERSON seconded the resolution, which was carried unanimously.

The election of the retiring auditors, Messrs. Deloitte, Dever, Griffiths and Co., was afterwards proposed and carried unanimously.

Sir THOMAS BAZLEY inquired whether any depreciation had been allowed for on machinery and on the accumulators.

The CHAIRMAN replied when he entered the concern he felt that the responsibility of the accounts must always rest upon their auditors; and as Mr. Griffiths was present he would request that gentleman to answer the question. The principle of writing off was a sound one, and one which would be dealt with as soon as practicable. He might, however, state that the Board of Trade was a very wholesome check upon them.

Mr. GRIFFITHS stated that no reserve had been made for depreciation on machinery or plant in the accounts this year. He thought that shareholders would admit, in the case of a company which was practically in its infancy, and had not by any means yet reached its power of work that it would be hardly fair, with so small a revenue as at present, to charge any depreciation. As a matter of fact, however, all expenses on repairs and renewals were charged against revenue.

Sir THOMAS BAZLEY said he thought that the machinery and plant were not worth the sum they stood at, and he considered that the depreciation ought to have been charged against the revenue account.

The CHAIRMAN replied that that was a matter of opinion. For his own part he certainly thought, as the auditor had said, that the time had not yet come when they would be justified in beginning to write off for

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depreciation. When the proper time arrived the shareholders might rely upon it that this was a matter which would be attended to, as has been done in the case of all the other companies with which he was connected.

A SHAREHOLDER inquired what was the utmost capacity of the present machinery in the way of lighting?

The CHAIRMAN replied that he believed the capacity was now about 250,000 lamps. Judging, however, from the way in which people were beginning to understand the electric light, he would not be astonished if they could supply a much larger number. A year ago the idea was put forward very strongly by the Chairman of the London Company that £1 per light was too little; but if the Metropolitan Company had been earning £1 a light on their 100,000 lamps they would now be paying their shareholders a very considerable dividend. They were now going for a much larger number of lights at a smaller price, and he thought that their average price would be more nearly 10s. per light than £1. In that case, however, they would get their business on a sounder and broader basis.

A SHAREHOLDER inquired whether the Company had power to lay on the wires to houses requiring the light.

The CHAIRMAN stated that they had the power, but there was a large number of firms engaged in the work of installation. If their Company entered on the work they would become to some extent monopolists, and they would have all this particular trade against them. That would not be desirable. It would also require a very large additional capital to carry out the work; and, all things considered, he thought it was better to let this work be done by others rather than by themselves.

A SHAREHOLDER observed that one of the Directors was engaged in the work of installations, and if it paid him would it not be to the interest of the Company to take part in the work also?

The CHAIRMAN stated that they were not prepared at present with the additional capital. They had the benefit of Mr. Verity's experience as to all this particular class of work. He believed that the work which was done by that gentleman's firm was first class. The more, however, that the Directors had looked into this matter, the more they had satisfied themselves that they had better not interfere with the general trade that was engaged in it. He stated at their meeting a year ago that he had been surprised, in driving along Oxford-street, to find that the electric light was so little used. However, its cleanliness, purity, and conveniences generally, were so marked that when people began to use the electric light they did not give it up. It was, he believed, more expensive than gas, but there were some gentlemen who were very acute who used the light—lawyers for instance, whose bills came to only a few shillings a year, for which they had all the advantages to which he had referred. There were other people who had 400 or 500 lamps, but they went away for six months of a year, and in their absence the light was not used. The Company had all these things to contend against. It was a new business, but, as he had said, it was growing day by day, and those who had the courage to stand by it would have their reward. He had been very glad at the discussion which had taken place, for he wanted the shareholders to be satisfied on every point.

A SHAREHOLDER asked whether there was any probability of any of the parishes taking the Company's lighting for the streets.

The CHAIRMAN replied that Mr. Claremont informed him that negotiations were going on at the present time in regard to this matter.

The Rev. WALKER FLOWER afterwards proposed a vote of thanks to the Chairman and Directors.

The motion was seconded and unanimously adopted.

The CHAIRMAN, in acknowledging the vote, admitted that he was a little disappointed at not having been enabled that day to announce a better dividend. He had thought that by doubling the number of their customers they might double the amount of their dividend; but he had mentioned the reasons why they had not succeeded in this. Those reasons were perfectly satisfactory to himself, and he was convinced that, as their customers were increasing, their dividend would improve, while their expenses, he reminded them, would not proportionately be greater. They had a good concern, and all that was required on the part of the shareholders was patience.

The proceedings then terminated.

Oriental Telephone Company (Limited).

An extraordinary general meeting of the members of the above Company was held at the offices of the Company, 14, Austin Friars, E.C., yesterday, Mr. William Addison in the chair. We have been favoured with the following report of the proceedings:—

The SECRETARY (Mr. Alex. B. Chalmers) read the notice convening the meeting.

It was moved by the CHAIRMAN, seconded by Mr. B. ST. JOHN ACKERS, and unanimously resolved:—

"*That the following resolution, passed at the ordinary general meeting of the Company held on the 27th April, 1892, be confirmed as a special resolution, viz., 'That the name of the Company be changed to The Oriental Telephone and Electric Company, Limited.'*"

West India and Panama Telegraph Company (Ltd.)

The following report of the Directors of this Company for the half-year ended December 31st last has been issued, and will be submitted to the thirtieth ordinary general meeting, to be held at Winchester House, E.C., on Tuesday, the 17th inst., at 2 p.m.:—

The Directors submit the accounts (which accompany the report) for the six months ended December 31, 1891. The amount to credit of revenue is £36,141. 2s. 8d., against £43,978. 19s. 8d. for the corresponding half-year of 1890, and the expenses have been £25,296. 3s. 11d., against £21,898. 3s. 11d. for the same period in 1890, leaving a balance of £10,844. 18s. 9d., which, with £5,255. 10s. 2d, brought from last account, makes a total of £16,100. 8s. 11d., with which it is proposed to deal as follows:—

	£	s.	d.
First Preference Shares—			
Dividend, 6 months to Dec. 31st, 6s. per share	10,368	18	0
Second Preference Shares—			
Dividend, 6 months to Dec. 31st, 6s. per share	1,400	14	0
Ordinary shares—			
6d. per share (free of income tax)	2,208	0	6
Balance to current half year's account	2,122	16	5
	£16,100	8	11

The traffic receipts for the six months show a decrease of £7,350. 15s. 8d., as compared with the corresponding period, due to the reduction of tariff, and to the condition of West India trade mentioned in the last report.

As anticipated, there has been an increase in the cost of repairs to cables, which amounts this half-year to £15,056 (as compared with £9,155 for the corresponding period). Of this sum £2,119 has been taken from the reserve fund.

The laying of the new cable between Trinidad and Demerara was completed by the Company's s.s. "Grappler" on November 18th last, thus affording duplicate telegraphic communication to the latter colony. All the colonies served by this Company are now connected by double lines of cables.

In exercise of the authority conferred upon the Board by resolutions passed at the ordinary general meeting of the Company, held on May 13, 1891, debentures to the amount of £80,000 (part of the £100,000 thereby authorised) have been issued at par, bearing 5 per cent. interest as from January 1st last. This issue has been applied to the payment of the £50,000 debentures, which fell due on December 31, 1891, and for the part payment of the St. Vincent-Barbados and Trinidad-Demerara duplicate cables.

In accordance with the Articles of Association, Henry Holmes, Esq., and Henry Weaver, Esq., retire at this meeting, and offer themselves for re-election. John George Griffiths, Esq., the auditor, also retires, and offers himself for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

ABELL'S ELECTRICAL ENGINEERING COMPANY (LIMITED).—This Company was registered on the 3rd inst., with a capital of £5,000, in £5 shares. The objects are to purchase or otherwise acquire the business of electrical engineers and machinists, now carried on by Thomas K. Abell, of The Stoops, Rainhill, Lancs., and William Hughes, of New Cross-street, St. Helen's, electricians, under the style of "Abell and Hughes," at the Steam Factory, Raglan-street, St. Helen's, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, manufacturers of electrical apparatus, machine and engineering tool makers, boiler makers, iron founders, &c. The signatories are:—

	Shares
Thomas K. Abell, The Stoops, Rainhill, Lancs., electrician	65
William Hughes, 22, New Cross-street, St. Helen's, electrician	55
P. B. Glover, Lime Grove, St. Helen's, mining engineer	50
James W. Glover, St. Ann's, St. Helen's, mining engineer	30
Samuel Urmson, Cowley Hill-lane, St. Helen's, colliery proprietor	20
W. J. Glover, The Ropery, Liverpool-road, St. Helen's	20
James Hodson, The Ropery, Liverpool-road, St. Helen's	20

Registered without Articles of Association.

MATHER AND PLATT (LIMITED).—This Company was registered on the 4th inst., with a capital of £200,000, in £10 shares, by Cooper, Dennison, and Co., 5, Shoe-lane, E.C. The objects are to acquire and take over as a going concern the business of steel and iron founders, mechanical and electrical engineers, and millwrights, now carried on by Messrs. William Mather and John Platt, at the Salford Iron Works, Salford, Lancashire, under the style or firm of Mather and Platt, and all or any of the assets and liabilities of the proprietors of that business in connection therewith, with a view to the above objects, to enter into and carry into effect an agreement which has already been prepared, and is expressed to be made between the said William Mather and John Platt of the one part, and the Company of the other part (a copy whereof for the purposes of identification has been subscribed by Edward Boutflower, solicitor), and to carry on the business of mechanical, electrical, and hydraulic engineers, manufacturers of machinery, tool makers, boiler makers, steel, iron, and brass-founders, metal workers, millwrights, machinists, electricians, iron and steel converters, chemists, metallurgists, &c. The signatories are:—

	Shares
William Mather, Salford Iron Works, Manchester, engineer	1
John Platt, Salford Iron Works, Manchester, engineer	1
Edward Hopkinson, Salford Iron Works, Manchester, engineer	1
Colin Mather, Salford Iron Works, Manchester, engineer	1
Thomas Thorp, Salford Iron Works, Manchester, engineer	1
John Milligan, Salford Iron Works, Manchester, engineer	1
Andrew W. Manson, Salford Iron Works, Manchester, cashier	1

William Mather, John Platt, Edward Hopkinson, and Thomas Thorp are to be the Managing Directors, and the two former shall each be entitled to hold office during his life, provided he holds not less than 1,000 shares, and the two latter so long as each holds 250 shares. William Mather shall be the governing Director, and shall have paramount authority so long as he holds not less than 1,000 shares. A sum not exceeding £4,000 yearly shall be appropriated as salary for the Managing Directors. In the

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absence of William Mather, the rights, powers, and authorities given to him (except the power of removing a Managing Director) may be exercised by John Platt, and after William Mather has ceased to be a Director, the powers, rights, and authorities given to him shall be exercisable by the said John Platt and Edward Hopkinson jointly. Every Managing Director shall hold not less than 250 shares, and every other Director not less than 100 shares. William Mather is the governor of the Company and Chairman of the Board so long as he remains a Director and is willing to act, and John Platt the Deputy-Chairman. When the said William Mather ceases to be the Chairman, John Platt shall, if then a Director, become Chairman and Edward Hopkinson Deputy-Chairman of the Company.

MISCELLANEOUS.—British Seamless Steel Tube Company (Limited); capital £20,000, in £10 shares and 100 £1 founders' shares.

BRITISH ELECTRIC TRAMWAYS AND GENERAL SYNDICATE (LIMITED).—In reply to inquiries made on March 9th last, as to whether the above-named Company was still in operation, a reply was received stating that a meeting of the Company was to be held in a short time, and the returns for 1890, 1891, and 1892, have now been filed. The annual return for 1890, made up to December 31st of that year has been filed. The Company was registered on December 15, 1888, with a capital of £10,000, divided into 1,850 "A" shares (which are entitled to an £8 per cent. Preferential Cumulative dividend), and 150 founders' shares of £5 each. At the time of making up the 1890 return, only seven "A" shares and 87 founders' shares were taken up, and upon all the founders' shares the full amounts had been called, and all calls (£435) had been paid, while upon the ordinary shares no calls had been made. The return for 1891, made up to December 31, 1891, and the return for 1892, made up to April 22nd, give similar results. Registered office: 81, Gracechurch-street, London, E.C.

ELECTRICAL WORKS, CONSTRUCTION, AND MAINTENANCE COMPANY (LIMITED).—The annual return of this Company, made up to December 31, 1891, was filed on April 13, 1892. The Company was registered on March 2, 1888, with a nominal capital of £2,000, in £1 shares, with objects as indicated by the title. At the time of making up seven shares had been taken up, upon which no calls had been made. The shareholders include James Whitehead (electrical engineer) and Robert Hammond (electrical engineer). No agreements for the acquisition of contracts, businesses, plant, &c., have been filed. Registered office: 15, St. Helen's-place, E.C.

ELECTRICITY AND ELECTRICAL ENGINEERING NEWSPAPER COMPANY (LIMITED).—The first annual return of this Company has been filed, showing that all the shares are taken up and fully paid.

HOBART TRAMWAY COMPANY (LIMITED).—Particulars respecting this Company appeared in *The Electrician* for March 11th; and in reference thereto an agreement was made on December 18, 1891, by which the Hobart Tramway Company of Hobart, Tasmania, agreed to hand over to the English Company the tramways, works, stock, and assets, complete to the satisfaction of the local authorities, and in a fit state to be handed over to Messrs. Siemens Bros. and Co. (Limited) for working the same. The consideration given to the Tasmanian Company by the English Company was £20,000 in paid-up ordinary shares and £35,000 in cash. By an agreement made March 24th last, a modification was made in the first-named agreement, by which the £35,000 to be paid in cash was altered to £25,000 in fully-paid shares, and £10,000 in First Mortgage Debenture Bonds.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).—The annual return of the above Company, made up to March 8th last, was filed on the 5th inst. The nominal capital is £812,000, in £10 shares, of which 41,600 have been taken up, the full amount called, and all calls paid.

JOHANNESBURG LIGHTING COMPANY (LIMITED).—The statutory return of the above Company, made up to March 24th last, was filed on March 30th. At the time of making up 8,400 preference and 17,570 ordinary shares had been taken up, all of which had been given in exchange for debentures in the late South African Company.

LIVERPOOL HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to January 11th, was filed on April 30th. The Company was registered in June, 1889, with a capital of £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. At the time of making up 107 (100 founders' and seven ordinary) shares had been taken up, the founders' shares being issued as fully paid to the parent House-to-House Company. Upon the ordinary shares no calls have been made.

PHOSPHOR BRONZE COMPANY (LIMITED).—The annual return of this Company, made up to April 1, 1892, was filed on April 21. At the time of making up, 7,335 ordinary and 8,375 preference shares had been taken up, the full amount called, and all calls (£78,550) have been paid. £90 has been paid on 18 ordinary and 18 preference shares forfeited.

SUNDERLAND AND DISTRICT ELECTRICITY SUPPLY COMPANY (LIMITED).—A letter from the solicitors to the above Company states that "nothing has been done since its registration, and that no business has been commenced." The Company was registered on February 13, 1889, with a capital of £100,000.

WARD ELECTRIC CAR COMPANY (LIMITED).—The annual return of this Company, made up to January 13th, was filed on March 7th last. The Company was registered on October 2, 1888, with a capital of £300,000, in £10 shares, to enter into and carry into effect an agreement with Michael R. Ward for the acquisition of certain letters patent, and to carry on the business of manufacturers of, and deal in, all things capable of being used in connection with the generation, distribution, supply, accumulation, employment or utilisation of electricity. The patents sold to the Company were No. 4,533, of 1887, and Nos. 2,876, 6,927 and 6,938, of 1888. At the time of making up all the shares had been taken up, and all issued as fully paid.

WILLANS AND ROBINSON (LIMITED).—The annual return of this Company, made up to April 20, 1892, was filed on April 25th. At the time of making up 2,200 shares had been taken up, of which 980 had been issued as fully paid. Upon 1,213 of the remaining shares the full amounts have been called, £30 on one share, £20 on six shares, resulting in the payment of £60,740, and leaving a call of £10 per share on six shares unpaid.

WOKING ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to November 19, 1891, was filed on March 22nd last. At the time of making up 2,112 shares had been taken up, of which 2,000 had been issued as fully paid, to the Electric Trust (Limited). Upon the remaining shares 25s. per share has been called, resulting in the payment of £85, and leaving £50 as yet in arrears. By an agreement made April 12th last between the Company and the Electric Trust (Limited) it is stated that the Woking Company was indebted to the Electric Trust for work done and goods supplied, and that the Electric Trust had consented to accept 843 shares in the Woking Company in payment of such indebtedness; it was therefore agreed that the Woking Company should forthwith issue to the Electric Trust 843 shares, Nos. 2,113 to 2,955, credited as fully paid up. Registered office: Board School Road, Woking.

CITY NOTES, &c.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—Particulars will be found in our advertising columns of the first drawing of 549 debentures of £100 each in the above Company. The debentures will be paid off at par on July 1st next, at the Alliance Bank, Bartholomew-lane, E.C., after which date interest ceases.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The following circular has been issued to the shareholders of this Company:—"You will no doubt have seen in the papers the prospectus of the South American Cable Company (Limited), and observed that it is based upon the annual returns of this Company for the past 5½ years. As this is so I would point out that the figures given in the prospectus as this Company's income from the South American traffic include, in fact, the Company's traffic from the West Coast of Africa and the Cape Colonies, which is not an inconsiderable item, and which cannot accrue to the new Company. It will be remembered that for some time past the South American traffics have been abnormally high, owing to a series of political and financial disturbances in various Republics of South America. With a more settled condition of affairs the traffic has now fallen to a more normal state, which resulted in the half-year ended December, 1891, in a receipt of £125,244, and for the period from January 1st last to date it has been at the rate of £109,000 for the half-year, as compared with £170,026 given in the prospectus for the corresponding half-year of 1891. The estimate, therefore, of traffic to a competing company, taken on the basis of £170,026, must be reduced by at least one-third. You will no doubt have also noticed in the public prints the intimation of the reduction of rates over the competing existing line *vid* Galveston and the West Coast of America. This reduction the Company have now to face, as well as any other reduction which might follow from the laying of an additional cable, and the competition of the Antilles cable when completed, all of which must materially and adversely affect the prospects of the new Company as set out in the prospectus. It is not apprehended that these circumstances will so prejudicially affect this Company as they must any competing line, the Brazilian Company having a joint purse agreement with the Western and Brazilian Telegraph Company, who cover the collecting ground for messages from Brazil and the East Coast of South America. Moreover, this Company have two cables between Lisbon and Pernambuco, and the duplication of the Western Company's line from Pernambuco to the River Plate will be completed in the course of a few days. Your Directors, therefore, consider that the revenue of £85,000 per annum which the new Company anticipates from their single cable is considerably over-estimated. Your Directors think it right that you should have this information before you, as they consider that whilst the new Company may prejudicially affect your interests, that Company will be unable to reap a corresponding advantage to themselves; and your Directors, therefore, recommend that you should not support the new enterprise.—By order, Richard Collett Secretary."

CALLS DUE.—Exeter Electric Light Company (Limited): 25 per centum on 10,000 £5 per cent. First Mortgage Debentures (*May 21*).—India Rubber, Gutta Percha, and Telegraph Works Company (Limited): £5 on 8,400 new £10 shares (*May 14*).

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 8th were £802, as against £695 for the corresponding period of last year, being an increase of £107. The total receipts to date, from January 1st last, amount to £15,220, against £13,942 in the corresponding period of 1891, being an increase of £1,278.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The Directors of this Company will recommend to the shareholders at the forthcoming general meeting, that dividends be

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paid at the rate of £6 per cent. on the preference and £1 per cent. on the ordinary shares, less income-tax paid for the half-year ending 31st March last, making with the interim dividends paid £6 per cent. per annum on the preference shares, and £3 10s. per cent. on the ordinary shares for the year. The transfer books will be closed from the 14th to the 16th inst., inclusive.

MESSRS. T. POTTER AND SONS (LIMITED).—The prospectus is issued of this Company; registered with a capital of £20,000, in £1 shares, to acquire the business of engineers and metal workers, carried on at South Molton-street, Oxford-street, and Hampstead. The Company propose to include electrical engineering in their operations. Application for the whole 20,000 shares is invited. Offices: 361, Oxford-street, W.

SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The Directors of this Company on Tuesday decided to pay an interim dividend at the rate of £8 per cent., free of income-tax, for the half-year ended March 31, to be distributed in accordance with the Articles of Association. The dividends are to be paid on the register as it stood on the 10th inst. The dividend warrants will be issued on the 31st inst. The dividend represents 2s. 9⅔d. per share on the ordinary shares, and 3s. 6½d. per share on the fully-paid shares.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended May 6, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,710.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 4.		Price Wednesday, May 11.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 11.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12 6	Anglo-American	48½	49½	48½	49½	5 6 1	Jan., Apr., July, Oct.	49	48½
£2,849,510	Stock	25/0	Do. Preferred	87½	88½	88½	89½	5 18 5	" "	89½	87½
£2,849,510	Stock	5/0	Do. Deferred	11	11½	11½	12	..	" "	11½	11½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	10½	11	10½	10⅜	7 8 10	Mar., June, Oct., Dec.	10 1/16	10 1/32
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	155	160	158	163	4 5 11	Jan., Apr., July, Oct.	159¾	159½
16,000	10	8/0	Cuba Submarine	10½	11½	11	12	6 13 4	February and August	11	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	16⅝	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3¾	3½	3¾	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10%	8½	9½	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅜	11⅝	11⅜	11⅝	6 0 2	Jan., Apr., July, Oct.	11⅝	11½
400,000	10	2/6	Eastern	14⅝	14⅞	14⅝	14⅞	4 10 5	" "	14⅞	14⅝
70,000	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 16 2	" "	15½	15 5/16
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107	110	108	111	3 12 1	May and November	110	109
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	108	106¾
250,000	10	2/6	Eastern Extension	15½	15⅝	15½	15⅝	4 11 1	Jan., Apr., July, Oct.	15⅝	15 5/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 1	February & August	109½	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	103	106	4 14 4	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	" "	103	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	100	103	100	103	3 17 8	February & August	102½	102
180,227	10	2/6	Globe Telegraph and Trust	10	10½	10	10½	5 2 5	Jan., Apr., July, Oct.	10½	10
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 18 1	" "	15⅝	15¾
150,000	10	5/0	Great Northern	19	19½	19	19⅝	4 7 2	Jan., April, and July	19⅝	19 5/16
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	105	109	4 11 9	March & September	108	..
17,000	25	37/6	Indo-European	39	41	39	41	6 1 11	May and November	41	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	5½	6½	5½	6½	6 3 1	April and October	5½	..
3,381	£100 Cert.	£1½	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	116	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3½	3	4	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	103¾	102¾
88,321	10	1/0	West India and Panama	1⅝	1¾	1⅝	1¾	..	" "	1 1/16	1⅝
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10 5/16	10
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
67,007	15	6/0	Western and Brazilian	9½	10	9½	10	7 10 5	" "	9 7/16	9½
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	6 7/16	6¼
30,364	7½	7/6	Do. 5 per Cent. Deferred	3½	4	3½	4	..	" "	3¾	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105	108	105	108	5 11 1	February & August	107¼	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105	108	105	108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	115	119	115	119	5 17 8	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	100	103	5 16 6	March & September	..	—
			TELEPHONES.								
224,850	14/0	3½%	Consolidated Telephone Const. & Maintenance	1 1/16	1 1/16	¼	⅜	6 10 10	May and November	¼	..
220,000	£1	4½d.	Oriental (11s. paid)	1 1/16	1 1/16	1 1/16	1 1/16	6 3 11	Yearly	¼	..
438,984	5	2/6	National	4½	4½	4½	4½	6 13 4	June and December	4 1/16	4½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13	13½	13	13½	4 8 11	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12	12½	12	12½	4 16 0	" "	12⅜	12¼
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	107	109	107	109	4 2 7	January and July	108½	107⅝
58,000	5	1/0	United River Plate	2	3	1½	2½	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	—	..	—
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7½	7¾	7½	7¾	..	—	7¾	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	2½	3½	..	..	..	—	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½	6	..	..	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½	6	..	..	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3⅜	3½	3⅜	3½	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5	5½	5	5½	..	March	..	..
111,000	5	..	London Electric Supply	¼	⅜	¼	⅜	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	7½	8	7½	8	..	..	7⅞	7⅞
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½	5½	4½	5½	—	..	..	—
18,680	£5	5/0	St. James' and Pall Mall	8½	8⅝	8½	9	—	..	8⅝	8½
7,900	£5	7%	Do. 7% Preference	7⅞	8¼	7⅞	8½	..	..	8 7/16	7 13/16
42,853	5	..	Westminster Electric Supply (fully paid)	6½	7	6½	6¾	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	3	3½	3	3½	..	..	3½	3
69,996	2	6%	Do. 6 per Cent. Preference	2	2½	2	2½	5 2 7	..	2 1/16	2 1/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	5¾	5½	5¾	5 16 8	January and July	5¾	5⅝
17,130	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅜	6½	5⅜	6½	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅝	2⅜	2⅝	—	—	2⅝	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	20	21	20	21	5 19 0	February & August	20⅝	20½
£210,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	102	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4	5	..	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	—
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛	⅜	⅛	⅜	..	..	..	—
78,949	5	5/7½	Swan United (£3. 10s. paid)	3½	4½	3½	4¼	9 0 9	May and November	4½	3¾
36,250	12	36/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 1	March and July	43½	42½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½	¾	..	..	..	..	..	—
—	£5	8%	Do. Preference (fully paid)	2½	3	..	..	..	—	..	—
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	3½	3½	2½	3½	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

The system of "Authorised Abstracts" inaugurated by the Council of the Institution of Electrical Engineers at the beginning of 1889 having been discarded, we resume this week, after a lapse of three years, the exercise of our own discretion in dealing with the question. At the date when the Council of the Institution thought fit to exclude reporters, we were in the habit of devoting considerable space to the reports of the discussions. Times have, however, changed since then, and we are now no longer able to give as much space as formerly. We propose, therefore, to publish carefully edited abstracts, and to give the speakers an opportunity of revising their remarks before they appear in print. In so doing we think that we are consulting the best interests both of the speakers, the exact meaning of whose statements when left in all their native vigour is not infrequently obscure, and of our readers, who for the most part have no time to wade through columns of ambiguities.

Among the physical units which have never "caught on" is the lux, partly perhaps because little attention has been paid to the science or art of illumination. When it was proposed by Mr. Preece at the Paris Electrical Congress in 1889 it was avowedly the name for the illumination due to one carcel lamp at the distance of one metre. The continental savants did not seem to appreciate it, and little has been heard of it for some time. At a meeting of the Royal Institute of British Architects on Monday last, Mr. Preece, after tracing the progress of artificial illumination from the time of Ajax to that of the Crystal Palace Exhibition, threw over the old-fashioned French carcel, ignored the scientific and cosmopolitan metric system, neglected a difference of twelve per cent., and brought forward the lux in an English garb as the illumination due to a candle at a foot. There is a purism which revolts at a candle-foot, because some ignorant person might rush to the unnecessary conclusion that, like a foot-pound, it is a quantity consisting of the product of two factors. The merit of the term "candle-foot" is that it is self-explanatory, and in this it resembles the word "pound-degree," which is not misleading, because it contains no allusion to the variation of specific heat with temperature, and which is, moreover, vastly preferable to "calory."

A "rule" was given by Mr. Preece to his fellow architects which may lead them into trouble if too confidently applied. "The great problem for solution was so to diffuse light throughout a room that it should be distributed uniformly over the working surfaces with an intensity of a lux." To do this, Mr. Preece recommended 16 c.p. lamps arranged at the corners of 8ft. squares, and hung 8ft. above the floor. So far, the advice was excellent for those who could afford it. The illumination will be very uniform, and its mean value will be very nearly one lux, according to its latest definition. But Mr. Preece went on to generalise, and discovered a coincidence between the 64 watts which are required to run a 16 c.p. lamp, and the 64 square feet illuminated per lamp, thus arranged. One watt per square foot is a very attractive "rule;" but if the candle-power of the lamp and its height above the ground be left out of consideration, it is as incomplete as a rule that one spoonful of paint should be used per square foot for painting a wall, without specifying the size of the spoon. The colour of the walls and ceiling, by-the-bye, is of about as great importance as the height of the lamp or its candle-power.

Much excuse is to be found for the scientific expert if he flatly contradict the assertions of opposing witnesses when pressed by a bullying or by an ingenious counsel, or when suffering from nervousness, or when drawn by enthusiasm into involuntary partisanship. But it is not easy to pass over completely discordant utterances of prominent scientific men at societies' meetings, especially when no burning argument is being debated, and when the utterances are unsupported by any experimental evidence. These remarks may appear to be a ponderous introduction to the comparison of two statements as to the absorption of light by ground glass; but fuss is made about the 98 or 100 per cent. conductivity of copper conductors, or similar differences in the electrical efficiencies of dynamos or transformers, and the question would be of very considerable interest if electrical engineers were really concerned with the purveying of light. Prof. Forbes gave it as his opinion, rather more than a year ago, that frosted glass absorbs little or no light, and that what is absorbed is due to the dirt which the frosting collects. Mr. Preece, using the expression ground glass, a rather different material, but pointing to the frosted bulbs of the glow lamps in the room of the Royal Institute of British Architects, informed his audience that they absorbed about 50 per cent., and when "a voice" said 60, Mr. Preece willingly adopted the correction. We have criticised Prof. Forbes' statement in these columns, but we are inclined to

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think that of the two his estimate is very much nearer the mark.

PHOTOMETRIC measurements of absorption by different kinds of glass were made more than ten years ago by Sir JOSEPH BAZALGETTE and Mr. T. W. KEATES for the Metropolitan Board of Works. They found that opal glass absorbed more than 59 per cent. The tests by Mr. GEORGE DEACON for the Liverpool Town Council gave 58 per cent., and those of M. ALLARD, on behalf of the Municipal Council for Paris, 40 per cent., while ground glass was found to cut off 25 to 35 per cent. Ground glass differs very widely in quality; the coarse grinding on a stone, the various degrees of sand grinding and sand blast, probably differ in their absorbing power; the fine grain used for photographic purposes, and the different kinds of etched or frosted glass are all included under the same name. Mr. CONRAD COOKE has found only 13 per cent. absorption in the case of a fine-etched gas globe. A dead-white surface acts as a reflector in a peculiar way. At whatever angle light falls upon it, most light is reflected in a direction perpendicular to it, and at other angles it falls off approximately as the cosine. Ground glass behaves in a somewhat similar way, and light is transmitted through it partly direct and probably partly as the cosine of the inclination with the perpendicular. Both the real loss and the variation in different directions are worthy of attention; and while it is impossible to remove the frosted surface from a bulb, the real absorption of these very attractive lamps ought to be definitely ascertained.

THE fusion of the sciences of electricity and optics which may some day come about, since the identity of light with electro-magnetic vibrations has been definitely proved, does not yet warrant the discussion of purely optical matters in these columns; but researches connected with radiant energy, especially where questions of wave length arise, present considerable interest to students of electrical science; and this is especially the case where radiations of a particular wave length suffer selective screening. In the *American Journal of Science* of the present month an account is given of some researches by Mr. HUTCHINS upon the radiation of atmospheric air. A column of heated air was caused to pass in front of a thermopile, and the radiation from the air alone was measured. So far, the experiments, interesting as they were, have no apparent connection with electrical matters; but it was found that when a very pure plate of quartz 0·5cm. thick was placed over the opening to the thermopile, with the air at 100°, no deflection could be obtained; and even when the temperature was raised to 200° there was no measurable effect. Without the quartz plate the deflection was 151. The quartz plate allows 93 per cent. of the sun's rays to pass it, 31 per cent. of the rays from red-hot platinum, and 3 per cent. of rays from lamp-black surface at 100°, being progressively opaque to waves of increasing length. The waves from heated air must therefore be of great length, since they seem incapable of penetrating quartz to any considerable degree. The question of screening has been attacked by Lord KELVIN, but there is still a lack of definite information about the screening properties of different substances for waves of different lengths. We have already alluded in these columns to the possibility of piercing fogs by radiations having sufficiently great wave lengths to occupy a position midway between ordinary light and those electro-magnetic disturbances with which HERTZ has made us familiar.

IT will be news to most English readers that Mr. EDISON is dissatisfied with American patent law, from which, so says the *Electrical World*, he has suffered so much that, backed by a powerful Telephone Company, he is going to get it altered. Many years ago we predicted that this insatiable patentee would never be content till he had secured a patent in his own favour for exclusive right of patenting; and it seems that he is now about to assert some such pretension, at all events so far as concerns the telephone. The story of the Berliner patent which we recently commented upon, is practically repeated in our "American Notes" this week, with the additional information that the claims are very broad—which means that they cover every existing telephone—and that the law which extinguishes those claims on the expiry of EDISON'S European telephone patents is likely to be rescinded or suspended for another 17 years. Nobody can doubt that at the end of that time the great magician will fetch out another "suspended" patent from up his sleeve, and repeat the operation at pleasure. Happily for us Europeans, his patents cannot be conjured into life again by the same process on this side the Atlantic.

THE address recently delivered by M. SÉRULLAS before the Société d'Encouragement on the subject of gutta-percha cultivation and collection, an abstract of which will be found elsewhere in the present issue, was without doubt suited to his audience. Any programme containing such items as methodical cultivation and thorough utilisation of existing resources and emancipation of a new French industry from foreign influences never fails to prove attractive across the Channel. We sincerely hope that M. SÉRULLAS is right and everyone else wrong; but the mere fact that English cable-makers, who have every inducement to encourage any practicable scheme for preventing the exhaustion of our gutta-percha supplies, should have persistently thrown cold water on M. SÉRULLAS and all his works is, to say the least, significant. An authoritative pronouncement as to the futility or practicability of gutta-percha plantations, and of obtaining *good* gum from leaves or bark, would seem highly desirable.

IN our issue of December 4th, 1891, when discussing the question of English electrical engineering exhibits at Chicago, we hazarded the suggestion that since the Exhibition authorities were so anxious to secure "representative" exhibits, they would do well to obtain a few specimens of good roads from this country. From a note in the *Engineering and Mining Journal* of New York we gather that something of the kind is on foot. One Col. ALBERT A. POPE, of Boston, has written to the Director-General of the Exhibition, "urging that strenuous efforts be inaugurated to make a comprehensive exhibit of improved roads and road-making machinery;" and the Exhi-

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bition grounds not permitting of sample European roads being laid down, it has been decided to obtain sectional models. If "object lessons" of this description are really to be a feature at Chicago, a new *raison d'être* for these shows will have been found. International Exhibitions will not in future be primarily demonstrations of foreign proficiency in this or that art, but will be devised so as to effectually show up native deficiencies. Solemn fasts, not big feasts, will then appropriately open the proceedings.

The Edison Station in Paris.—On March 31, 1892, the Compagnie Continentale Edison had 43,942 10-c.p. lamps connected to its Paris mains.

Stockholm.—The Town Council have granted a concession for an electric tramway, running to Djursholm. A steam railway on this route had been previously authorised.

Société Internationale des Électriciens.—The President and Council of this Society, mentioned on page 27 of our last issue, are for the year 1893-4, and not for 1892-93, as stated.

The Engineering Exchange.—The Engineering Exchange will be officially declared open in the Exchange Room of the Jerusalem, Billiter-buildings, E.C., on the 31st inst., at 12 o'clock.

The Lighting of the City of Mexico.—The city of Mexico, says *El Telegrafo Espanol*, is lighted by 299 arc lamps of 2,000 candles, 145 arcs of 1,200 candles, 408 gas lamps, and 1,534 oil lamps.

Exeter.—At the last meeting of the Town Council a resolution was passed stating that it was desirable to light the open spaces of the city by electricity, provided it could be done at reasonable cost.

The House of Commons Telephone.—The telephone in use at the House of Commons was on Wednesday for the first time placed in direct connection with Birmingham, and messages were transmitted to that city, Wednesbury, and West Bromwich.

The Electrical Utilisation of Water Power in Switzerland.—A sugar refinery at Monthey, near Vevey, is about to be fitted with two 125 H.P. 1,000-volt continuous-current motors. Power will be derived from a 110ft. fall, about three-quarters of a mile distant.

Cable Interruptions and Repairs:—

	Date of Restoration.
REPAIRS.—Siberian Landlines	May 14, 1892.
	Date of Interruption.
INTERRUPTIONS.—Bolama-Bissao Cable	April 23, 1892.
Mossamedes-Benguella Cable.	May 19, 1892.

Royal Society.—The following Papers were down for reading yesterday:—"On the Changes Produced by Magnetism in the Length of Iron and other Wires carrying Currents," by Mr. Shelford Bidwell, F.R.S.; "On the Measurement of the Magnetic Properties of Iron," by Mr. T. Gray.

Cable Duplication.—The Telegraph Construction and Maintenance Company's s.s. "Scotia" has completed the duplication of the Western and Brazilian Company's Santos-Chuy cable. This completes the direct duplicate service between Brazil and Lisbon, while from the latter place there are triplicate cables to England.

Institution of Electrical Engineers.—A students' meeting was held at the library of the Institution on Friday, 13th inst., Mr. Gisbert Kapp presiding. Mr. Haycroft, hon. sec., read some "Notes on Alternate Current Transformers." At the next meeting, Friday, May 27th, Mr. McDouall will read a Paper on "Electrometers."

Perth (Western Australia).—A report has been presented by Mr. W. J. Hancock (Superintendent of Telegraphs) to the Perth City Council, recommending that a tender by Messrs. Crompton and Co., offering to light the city with 126 20-c.p. incandescent lamps and nine 15-ampere arcs for the sum of £3,750, and an annual charge for seven years of £520, be accepted.

Taunton.—At a meeting of the Town Council last week, held to consider the purchase of the electric light works, there were three special points before the Council for consideration. First, that the Town Clerk be instructed to obtain a Provisional Order; second, that the system of lighting now in use in Taunton be continued for the present; and, third, that a Committee be appointed to negotiate with the Electric Lighting Company, with a view to purchase, on the basis of the report of Mr. Kapp. These three proposals were agreed to.

A Large Electric Locomotive.—According to the *Elektrotechnischer Anzeiger*, MM. Brown and Boveri, of Baden, are about to build a locomotive which will be one of the most powerful in the world, and quite the most powerful of those driven by electricity. It is to be provided with motors of a total horse-power of 1,500, which can be raised to 2,000 horse-power. One motor is placed direct on each of the eight axles, and the locomotive is designed for a speed as high as that ordinarily used on steam locomotives. It is expected that it will be ready to be tested by the end of the present summer.

York.—At a meeting of the Town Council on Tuesday last, a report of the Streets and Building Committee, with reference to the proposed introduction of the electric light by the Corporation, came up for discussion. It was stated that there had been applications for 2,700 lights by private consumers, and that the Corporation would require about 2,500 more. The Committee's report recommending the borrowing of £15,000 for electric lighting purposes was adopted after some discussion. Mr. Crompton was present, and replied to the various questions put to him by members of the Council.

Dundee.—The report by Prof. Kennedy in reference to the proposed municipal central station has just been issued. The engineers are Messrs. Urquhart and Small, and they propose to adopt the three-wire system, with storage batteries As the result of a personal examination of the area proposed to be illuminated, Prof. Kennedy approves of the specifications of the electrical engineers, but suggests that the mains should be continued to the residential district near to the station. At a meeting of the Gas Commissioners on Tuesday, the report was read and adopted, and it was resolved to invite tenders for boilers, steam piping, engines, dynamos, batteries, and mains. The work will be gone on with without delay.

The Electrical Industries in Japan.—A report has just been laid before Parliament, giving the results of inquiries instituted by Her Majesty's Consuls in Japan into the various native industrial enterprises that have sprung up in late years in that country. There are, it is stated, three factories—two in Tokio and one in Yokohama—where insulated and silk-covered wire, incandescent lamps and other goods are produced. According to the report the articles produced are, "on the whole, of very inferior quality, but in many cases their cheapness enables them to compete successfully with goods imported from abroad, chiefly the United States." Dynamos are still imported from America, all attempts to manufacture them on the spot having failed.

Geneva.—M. Turrettini, Director of Public Works to the Geneva Municipality, has just laid plans before that body for a large new hydro-electric installation at Chèvres, on the Rhone, a few miles below Geneva. When complete the station will comprise 15 800 H.P. turbines, only three being immediately contemplated. The total cost is estimated at £225,000. Tenders for the turbines have been asked from Escher, Wyss et Cie., of Zürich, and MM. Faesch et Piccard, of Geneva; tenders for the electrical plant having been asked for from the Oerlikon Works and MM. Brown et Boveri, of Baden. The total capital expenditure of the Geneva Municipality on this and other hydraulic schemee will exceed £400,000. M. Turrettini urges an immediats decision on the Chèvres scheme, in order that the work may be commenced in the autumn.

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Accident to the s.s. "Norseman."—A Lloyd's telegram, dated May 13th, off Chuy, states that the "Norseman," belonging to the Western and Brazilian Telegraph Company, which had been engaged with the "Scotia" in duplicating the Santos-Chuy section of the Company's cable, experienced a heavy gale on the 10th, and sprung a leak, which put out the fires. The pumps got choked, and the crew were engaged all day and night baling with buckets, but the water gained. The weather moderated on the 12th, and during the night all hands were transferred to the "Scotia." When left the "Norseman" had 11ft. of water in the engine-room and 3ft. 6in. in the after hold. Later advices state that the "Scotia" towed the "Norseman" to Monte Video, where she arrived on the 16th inst., and having been placed in shallow water, is now being pumped out. It is expected that she will be in dry dock in a few days, when a survey will be held.

The "Board of Trade Unit."—With reference to Lord Kelvin's letter in our last issue, Mr. Binswanger writes that he considers the word "unit" extremely misleading and likely to give rise to confusion. All other electrical units of measurements have received short and appropriate names, says Mr. Binswanger. Why make an exception of the kilowatt-hour? As an instance of the misunderstanding arising out of the use of the word "unit," our correspondent cites the following:—"Meter dials are all divided into multiples of tens, and are logically and grammatically denominated units, tens, hundreds, and so forth. But as meters' indications have generally to be multiplied by constants, and, as is mostly the case, each stroke on the dial denotes one ampere-hour at 100 volts, or one-tenth of a supply unit, it is clear that we shall lead consumers into confusion by printing on the first dial 'units,' whilst it really represents only one-tenth of a Board of Trade Unit."

Obituary.—We regret to record the death of Mr. William Ford, barrister-at-law, which took place at his residence in London on the 14th instant. The deceased gentleman was for many years connected with submarine cable companies, and was a Director of the Globe Telegraph and Trust, the Direct United States Cable, and the West India and Panama Telegraph Companies. He was much esteemed by his colleagues.—We regret to record the sudden death from heart disease, on the 14th inst., at Singapore, of Captain William Fawcus, of the Eastern Extension Company's cable steamer "Sherard Osborn." Captain Fawcus joined the Eastern Extension Company's service in 1884 as first officer of the s.s. Agnes, and was transferred to the "Sherard Osborn" in 1886; and upon the resignation of Captain Francis Worsley in 1887 he assumed the command of the vessel. Captain Fawcus had much experience in cable repairs, and the last work on which he was engaged was the triplicate cable between Singapore and Penang.

The Chicago Exhibition Telephone Exchange.—A contract for a telephone service has been signed by the Exhibition authorities and the Chicago Telephone Company. By its terms, says the *Western Electrician*, the Chicago Telephone Company agrees to establish a telephone exchange and its American District telegraph service "on the most improved plan" at Jackson Park, to be connected with the exchange system of Chicago, so that for every seven exchange telephone subscribers in the Exhibition grounds at least one copper metallic circuit shall be furnished. Some five and twenty call offices are to be erected in the grounds for the use of the general public. Nothing but long-distance instruments and metallic circuits will be used. It is expected that the long-distance copper line to New York will be ready for use by the time the World's Fair is opened, and connections will be made directly with this line at Jackson Park, independent of the Chicago exchange and the city under-ground system.

Prof. Ayrton.—A complimentary dinner was given to Prof. Ayrton on the 13th inst., at the Holborn Restaurant, to commemorate his election to the Presidential chair of the Institution of Electrical Engineers, and as an expression of admiration from a few of his students. The function was inaugurated under the presidency of Mr. W. B. Esson. During the evening an illuminated vellum testimonial, signed by "old boys," was presented to the Professor. The signatories were:—L. B. Atkinson, Frank Bailey, H. J. Dowsing, W. B. Esson, W. Geipel, Reg. J. Jones, W. M. Mordey, Fras. Mudford, Frank Nalder, J. Probert, A. Reckenzaun, F. M. Rogers, H. W. Sayers, W. B. Sayers, R. Percy Sellon, Albion T. Snell, W. E. Sumpner, Ernest B. Vignoles, R. Mullineux Walmsley, H. D. Wilkinson, and Arthur Wright. Among the guests were Mr. Preece, Prof. Silvanus Thompson, Prof. Perry, Mr. Swinburne, and Mr. F. H. Webb. The dinner was in every way a success, and the "speech time" was one of the liveliest on record in the annals of electrical engineering.

The Electric Supply Rates in Paris.—Many Parisians, more ingenious than honest, have been inspired by the great difference in price of the electric current when used for power and for light with the brilliant idea of installing dynamotors in their houses. According to the *Bulletin International d'Electricité*, the latest advocate of this scheme is M. Laur, a well-known member of the Chamber of Deputies. According to the *cahier des charges* imposed on the electricity supply companies in Paris, the maximum charge for the kilowatt hour is 1 franc 50 centimes for lighting purposes, and 60 centimes for power purposes; so that, making no allowance for the cost of attendance, &c., and assuming that the supply companies all charge the maximum, it is easy to work out that the adoption of a dynamotor of ordinary efficiency would result in a saving of about 30 per cent. As a matter of fact, the prices charged by the various companies are as follows:—Société Edison, 1 franc 23 centimes; Société Parisienne, 1 franc 9 centimes; Société Popp, 1 franc 25 centimes; and Société de la Place Clichy, 1 franc 30 centimes.

Gas Engines for Dynamo Driving.—The German Imperial Continental Gas Association, Dessau, after running dynamos by means of gas motors for five years, tabulates the advantages of the system as follows, says the *Gas World*:—1. Small amount of space required. 2. Small consumption of water: 5 to 6 gallons per horse, or less. 3. No coal to carry: independent of railway station. 4. No smoke. 5. No explosions. 6. Cheaper than steam engines in respect of (1) ground required; (2) relative convenience of gas motors rather than steam engines in a town, whence greater choice of place within a town, and smaller distances to lay cables; (3) gas motors above 100 H.P. being cheaper than steam-engines, boilers, chimneys, &c. 7. Less loss of electricity, because station more favourably situated. 8. Less attendance and wages. 9. Exact control over fuel. 10. More regular working, and greater security of power to meet unforeseen demands. 11. Cost of fuel can be reckoned (the gas company running the electric station) at the full cost price of the gas supply. Gas motors of 120 horse now cost to put up about half what steam engines do; and in the future the price of still larger gas motors may be expected to fall.

The Sawyer Telephone Cable.—In order to produce a telegraph and telephone cable having low inductive capacity and high insulation, and which at the same time should be light, flexible and inexpensive, Mr. W. H. Sawyer, of the American Electrical Works, Providence, R.I., has, says the *Electrical Engineer* of New York, recently devised the following arrangement:—A number of insulated conductors, usually four in number, are woven at regular distances apart with some fibrous material into a continuous flat ribbon, which is then wound into a spiral tube, leaving a central air space. The conductors are so woven with the fibrous material as to form an open-mesh work between the wires, and when the ribbon is twisted into a helical form the wires are all approximately equidistant, thus securing the lowest inductive capacity between them. Upon the spiral tube thus formed is wound a second ribbon, similar to the first, but wound in a reverse direction; thus securing the greatest separation of conductors within the least possible space. In forming the complete cable a number of sections thus constructed are grouped together and inclosed in a lead sheath, or a series of successive ribbons carrying the braided wires may be wound upon the spiral tube until the cable is built up to the desired diameter, and then inclosed in a lead sheath, each ribbon being wound in a reverse direction to that of the underlying section.

Magnetic Iron Rust.—At the recent meeting at Hobart (Tasmania), of the Australasian Association for the Advance-

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ment of Science, Prof. Liversedge, of the University of Sydney, read a suggestive Paper on the rusting of iron. The author remarked that in books upon chemistry it was usually stated that iron rust was composed of the hydrated sesquioxide of iron; but on examining a very large number of specimens of rust from many different places, and from iron articles of various kinds, and formed under very varied conditions, he found that in almost every instance the rust contained more or less magnetic oxide; indeed, in some cases the rust, although presenting the usual rust-brown colour and appearance, was, when powdered, practically altogether attracted by the magnet. The specimens of rust which first drew the author's attention to this subject were large rust scales obtained from some old tramway metals, which he was led to collect and examine on account of their resemblance to the crust so often present upon metallic meteorites. The production of this magnetic oxide does not seem to have been due to the presence of mill scale, because, when bright iron wire, plates, rods, nails, &c., were artificially rusted in many ways with free access of oxygen, in almost every instance a large amount of magnetic oxide was formed. These observations have some practical bearing upon the problem of the preservation of wrought-iron structures from rust.

American Institute of Electrical Engineers.—The general meeting of this Institute will be held at the Grand Pacific Hotel, Chicago, on Monday, Tuesday, and Wednesday, June 6th, 7th, and 8th. The following are some of the Papers in preparation for that occasion:—"Electric Coal Mining Machinery," by Mr. Elmer A. Sperry; "On the Electro-Magnetic Field," by M. I. Pupin, Ph.D., of Columbia College; "Long-Distance Transmission for Lighting and Power," by Mr. Charles F. Scott; "Electric Heating," by Mr. C. E. Carpenter; "A Dynamo Indicator, or Instantaneous Curve Writing Voltmeter," by Prof. George S. Moler, of Cornell University; "The Magnetic Properties of Sheet Iron," by Mr. Milton E. Thompson, of Cornell University; "A Discussion of Circuits containing Resistance, Self-Induction, and Capacity," by Messrs. Bedell and Crehore, of Cornell University; "A Life and Efficiency Test of Incandescent Lamps," by Prof. B. F. Thomas and Messrs. P. Martin and R. H. Hassler; "Notes on Wiping Contact Methods for Current and Potential Measurement," by Prof. B. F. Thomas; "Series Electric Traction," by Mr. Nelson W. Perry; "Oil *v.* Air as Insulation," by Dr. J. B. Williams, of New York; "On the Electrolytic Refining of Copper," by Lieut. F. B. Badt; "The Photography of Alternating Current Curves," by Dr. Edward L. Nichols, of Cornell University; "The Reversal of Polarity in Plating Dynamos;" also on "Dynamos for Continuous-Current Circuits," by Prof. Harris J. Ryan, of Cornell University. Papers are also expected from Mr. H. Ward Leonard, Mr. Nikola Tesla, and Prof. Elihu Thomson.

Petroleum Engines.—In a Paper on this subject recently read before the Institution of Civil Engineers, Prof. Unwin stated that there was no clear evidence that in this country steam could be produced as cheaply from oil as from coal. In a petroleum engine the thermodynamic efficiency might be expected to be more than double that of a steam engine and boiler. In the Priestman engine a jet of oil, controlled by the governor, and a current of air, were mixed in a spraying nozzle, which reduced the oil to very fine particles. The mixed air and spray were then received in a vaporising chamber, heated by a jacket through which the exhaust of the engine passed. During the suction stroke an additional air supply, also regulated by the governor, entered the vaporiser and drove forward the charge into the cylinder. The charge was compressed, ignited by an electric spark, expanded doing work, and finally was exhausted, the cycle being the same as in the Otto gas engine. In a trial of a 5 H.P. Priestman engine, running normally at 200 revolutions, comparing the fuel consumption with that of a steam engine, and taking 1lb. of oil as equivalent to 1¼lb. of coal, the consumption in the oil engine was equivalent in the respective trials to 1·18, 1·23, and 1·02lb. of coal per B.H.P. per hour. The lowest known consumption of steam in steam engines was 1·245lb. per I.H.P. per hour, in a large triple Sulzer engine. This would correspond to 1·61lb. of coal per B.H.P. On all occasions when Prof. Unwin had had one of these engines under observation, it had been started without difficulty, and worked without any hitch. Amongst the special applications might be mentioned dynamo driving in country districts.

The National Telephone Company and its Sheffield Subscribers.—At the quarterly meeting of the Sheffield Town Council last week, the following letter was read from the General Manager of the National Telephone Company to the Town Clerk:—

'Dear Sir,—I observe from yesterday's Sheffield evening paper that notices have been given of an amendment to certain minutes of you Highways Committee relating to the granting to this Company of certain licences for the laying of telephone wires; and my object now in writing to you is to express the hope that having regard to the fact that a meeting will take place in the course of a few days between the Committee which was appointed at yesterday's meeting of subscribers and the Directors of this Company, the amendment may not be proceeded with. As I explained at the meeting yesterday, the Directors of this Company are fully prepared and intend to meet the wishes of the Sheffield subscribers, and it is quite unnecessary for the Town Council to bring pressure to bear by withholding facilities for the running of wires. I would point out that the Town Council by so doing would not only inconvenience the Company, but also many of their own constituents. It is, of course, a matter of great regret that a tariff has been suggested which meets with such universal disapproval, but I cannot help thinking that the object of the Directors in putting it forward has been greatly misunderstood. It is not now to the point, but in fairness to the Company, I may mention that from the statistics placed before the Board, and gathered from other parts of the country, the Directors believed that the proposed tariff would operate in the interests of the great majority of the subscribers. I can only further add, that the Committee when they meet the Directors will find them willing and anxious to meet their views, and to arrange a tariff which will satisfy Sheffield, and that under these circumstances it is unnecessary for the Town Council to whip a willing horse by denying wayleave facilities. May I ask you to be kind enough, if necessary, to place this letter before your Town Council?"

On Thursday last week Mr. G. F. Preston, district manager of the National Telephone Company, issued a circular withdrawing the obnoxious tariff, promising a revised one, and announcing that subscribers to the National exchange were at liberty to communicate with those on the local exchange and *vice versâ* without extra charge. A few days later the Duke of Marlborough announced that the New Telephone Company proposed shortly to seriously canvass the town.

The Incandescent Lighting of the Chicago Exhibition.—The trouble over the incandescent lighting contract for the World's Fair is by no means over, says the *Western Electrician*, in its issue of May 7th. At the time that the Committee on Grounds and Buildings decided to give the work to the Thomson-Houston-Edison Company at its last offer of $5·95 per lamp, nearly everybody considered the matter as settled. But the contract was not signed, and when Mr. Westinghouse reappeared on the scene, the whole subject was left to the discretion of Mr. Higinbotham, vice-president of the Exposition Company. On Tuesday morning, May 3rd, Mr. Higinbotham made up his mind as to his duty in the matter. To a representative of the *Western Electrician* he said: "I have come to the conclusion not to comply with the recommendation of the Committee on Grounds and Buildings, and sign the contract. I shall do my duty in the matter by reporting to the Committee this afternoon in favour of re-advertising for bids. I think that the Committee on Grounds and Buildings should begin all over again." Mr. B. E. Sunny, Western manager of the Thomson-Houston Company, characterises the proposition to re-advertise for bids as "extraordinary," and says: "The matter was settled three weeks ago by a formal resolution of the Grounds and Buildings Committee. We were given the contract, and it does not seem to me possible that the Committee can go back on its action. Such action would be contrary to all business principles. I do not know what we shall do in the event that the Committee takes action with a view of reversing its decision." There appears to be but little doubt, says our Chicago contemporary, that, whatever the result to the electric companies, the World's Fair will get its incandescent light at a very cheap rate. One feature of the situation is the possibility that the Edison Company may seek legal means to prevent the World's Fair from using incandescent lamps of other than its own manufacture, if the Westinghouse Company should get the contract.

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TRANSFORMER DESIGN.*

BY DR. J. A. FLEMING, M.A.

We may now consider the full specification for a transformer. Let it be required to design a transformer, say, for transforming W watts of electric power from a pressure of E_1 volts to one of E_2 volts. Required to find the sizes of wires and numbers of turns of the two circuits, and the size of the core and waste of energy in it, under the conditions that the maximum induction density in the core shall not exceed B C.-G.-S. units and the current density in the circuits not exceed 1,000 amperes per square inch. Let other limitations imposed be that the waste of energy in the copper shall not be more than 2 per cent. of the full load.

Since the transformation ratio and power are known we may take it that approximately the full-load primary current will be $\frac{W}{E_1}$ amperes, and the full-load secondary current a little less than $\frac{W}{E_2}$ amperes. Let I_1 be the $\sqrt{\text{mean}^2}$ value of the full load primary current and R_1 the resistance of the primary circuit, and let I_2 and R_2 be the same quantities for the secondary circuit. Furthermore, let N_1, N_2 be the number of turns of wire on these circuits, and l_1 l_2 the lengths, and σ_1, σ_2 the cross-sections of these wires.

At full load the total rate of dissipation of energy in the copper circuits is

$$I_1^2 R_1 + I_2^2 R_2 = K D.$$

But, $$R_1 = \frac{\rho l_1}{\sigma_1} \qquad R_2 = \frac{\rho l_2}{\sigma_2}$$

where $\rho = \frac{16}{10^7}$ ohms, or is the specific resistance per cubic centimetre of copper at ordinary temperatures—that is, the resistance of one cubic centimetre in ohms across opposed faces. Substituting these values of R_1 and R_2, we have

$$D = \frac{I_1}{\sigma_1}\rho I_1 l_1 + \frac{I_2}{\sigma_2}\rho I_2 l_2 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now $\frac{I_1}{\sigma_1}$ and $\frac{I_2}{\sigma_2}$ are the current densities in these wires. This current density ought not to exceed 1,500 amperes per square inch, or 240 amperes per square centimetre.

Put, therefore, $$\frac{I_1}{\sigma_1} = \frac{I_2}{\sigma_2} = 240,$$

and we have

$$D = \frac{240 \times 16}{10^7}\{I_1 l_1 + I_2 l_2\} \quad . \quad . \quad . \quad . \quad (2)$$

But in practice $I_1 l_1$ will always be nearly equal to $I_2 l_2$. Hence we arrive at

$$D = \frac{868}{10^6} I_1 l_1 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\left.\begin{aligned} \text{therefore} \quad l_1 &= \frac{10^6 D}{868 I_1} \\ \text{also} \quad \sigma_1 &= \frac{I_1}{240} \\ \text{and} \quad R_1 &= \frac{16}{10^7}\frac{l_1}{\sigma_1} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

These last three equations give us the length, section, and resistance of the primary wire when we know the full load primary current and the total power, D, permitted to be dissipated in the copper circuits when the transformer is fully loaded.

For example, let us take the case of a 30 H.-P. closed-circuit transformer and find all the quantities.

The full load of the transformer is 30 H.-P. = 22,400 watts. Suppose, as most likely, that 300 watts, or say, 1·3 per cent. of the full load, is to be allowed to be wasted in the copper circuits at full load, and that the transformer is to be designed for converting from 2,000 volts to 100. Then the full load primary current I_1 is 12 amperes. Therefore we have

$$l_1 = \frac{10^6 \times 300}{868 \times 12} = 30{,}000 \text{ centimetres.}$$

$$\sigma = \frac{12}{240} = 05 \text{ square centimetre.}$$

$$R_1 = \frac{16}{10^7}\frac{l_1}{\sigma_1} = 96 \text{ ohm.}$$

This gives us the length, section, and resistance which the primary circuit ought to have. Having found the dimensions of the primary circuit, we may obtain approximately those of the secondary by the division of l_1 by the transformation ratio $\frac{E_1}{E_2}$ and multiplication of σ_1 by the same fraction. Thus for the above transformer, the length of the secondary will be 1,500 centimetres, and its section 1 square centimetre, and its resistance ·0024 ohm.

The next step is to find the dimensions of the magnetic circuit. These are easily found, thus:—The primary electromotive force is to have a $\sqrt{\text{mean}^2}$ value in volts equal to E_1. Hence, its maximum value is $\sqrt{2}\,E_1$. If the maximum value of the induction density is **B**, and if S is the cross-section of the magnetic circuit, then the value of the quantity $p\,\mathbf{B}\,S\,N_1$ is always nearly equal numerically to $10^8\sqrt{2}\,E_1$, where $p = 2\pi n$ and N_1 is the number of primary turns, and **B** is measured in C.-G.-S. units. Hence,

$$S N_1 = \frac{10^8 \sqrt{2}\,E_1}{p\,\mathbf{B}} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

If we suppose the cross-section of the magnetic circuit to be a square, whose side has a length $\sqrt{S}$, then, since l_1 is the length of the primary wire, we have, very nearly,

$$\frac{l_1}{4\sqrt{S}} = N_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Therefore from (5) and (6)

$$\sqrt{S} = \frac{4\sqrt{2}\,E_1\,10^8}{p\,\mathbf{B}\,l_1} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

This gives us the area of cross-section of the magnetic circuit.

For instance, for the transformer referred to above, we have $E_1 = 2{,}000$, $\mathbf{B} = 10{,}000$, $n = 70$, $p = 440$, and $l_1 = 30{,}000$.

$$\therefore \sqrt{S} = \frac{5{\cdot}66 \times 2000 \times 10^8}{440 \times 10000 \times 30000} = 9 \text{ centimetres nearly.}$$

Therefore, the magnetic circuit should have a cross-sectional area of 80 or 90 square centimetres.

To find the mean length of the magnetic circuit we must know the volume of the iron. This we can find at once if we know what total loss is to be allowed in the iron. For, supposing l to be the mean length of the magnetic circuit, then $S\,l$ is very nearly the volume of the iron, and if the total loss to be allowed in the iron is given and the maximum induction density, we can find the total volume of the iron which will permit this to be the case. It has been shown by Mr. Steinmetz (see *Electrician*, February 12, 19, and 26), that the iron core loss in a transformer can be calculated from the equation $W = \alpha n \mathbf{B}^{1\cdot6} + \beta n^2 \mathbf{B}^2$ when α and β are certain constants, and n is the frequency and **B** the maximum induction density in the core, and we can therefore calculate from the frequency, dimensions of iron bands, and the maximum induction density, the loss in watts per cubic centimetre in the core due to eddy currents and hysteresis. On applying this formula to real cases we find that the loss in laminated iron cores of the usual kind, worked at the usual induction densities, varies between one watt per 20 cubic centimetres of iron to one watt per 50 cubic centimetres of iron. This last is a liberal allowance. Hence, if we know the total loss in watts to be allowed in the transformer core and multiply this by 40 or 50, we shall have a good approximation to the volume of the iron necessary. If we take 50 cubic centimetres per watt we shall not be stinting the core of iron. In the present case, take 30 cubic centimetres per watt. In the case of the transformer con-

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sidered, viz., a 22·4 unit one, we allowed 300 watts to be wasted in copper losses. Let 500 watts be decided upon as allowable for the iron losses. We have then to ask, what volume of iron will allow 0·033 watt to be wasted per cubic centimetre. Obviously,

$$\frac{500}{\cdot 033} = 15{,}000 \text{ cubic centimetres.}$$

Therefore, since the volume of the iron is $S\,l$,

$$S\,l = 15{,}000$$

and if S is taken as equal to about 90 square centimetres, we have

$$l = 166 \text{ centimetres nearly.}$$

Hence the mean length of the magnetic circuit must be 166 centimetres.

We can, therefore, draw the section of the iron core, or outline of the core plates. It will be as in the figure. The central web must have a width of 10 centimetres, and the other dimensions must be so arranged that, whilst the apertures in the plate (shaded portions) have a maximum area, the length round the dotted line is not more than say 150 centimetres. It is obvious that, whilst still maintaining the necessary length of magnetic circuit, it is possible to vary the relative magnitudes of the sides a and b of the rectangular holes. But since all the wire to be wound on the transformer has got to be wound through these holes, it will be often necessary to so choose a and b that we get the maximum size of aperture in area consistent with maintaining the magnetic circuit length constant,

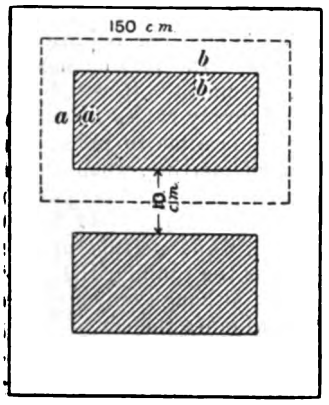

Diagram of Core Plate.

and to do this by making a equal to b. We have then finally to know the number of turns of wire in each circuit.

Roughly speaking, this will be equal to $\frac{l}{4\sqrt{S}}$, where l is the length of the wire and $\sqrt{S}$ is the length of the side of the section of the magnetic circuit. If l is equal to 30,000 centimetres, as above found for the transformer in question, this rule gives us $N_1 = 750$ as the approximate number of primary turns, and hence $N_2 = 37$ as the approximate number of secondary turns.

We have found, then, the length, size, resistance, and number of turns of each circuit, and the dimensions of the magnetic circuit.

We can then calculate the relative volumes of iron and copper. Taking the case in consideration, we find the total volume of copper to be 3,000 cubic centimetres, and that of the iron 14,300 cubic centimetres. A little consideration will show that, since the wire on the coils has all to be wound through the aperture in the core, the limitation to the diminution of the core, and therefore to the loss in the iron, is to be found in the necessity for having a certain sized hole to get the wire wound through. If we calculate the area of copper exposed on cutting through the whole of the coils by a dimetral cut in the case of the transformer considered, we shall find that it amounts to about 74 square centimetres, and even if we allow three times this area for insulation, there will still be abundance of room left in the aperture of 32 × 32 centimetres to get all the wire laid in. Hence in this case we could with advantage reduce the iron volume and waste less in the core. It would require further considerable discussion to show how the best dimensions of the core can be obtained. It may be pointed out, however, that the above rough sketch of a predetermination of the constants of a transformer shows that if we are given—

(1) The primary and secondary electromotive forces;

(2) The required output of the transformer;

(3) The amount or fraction of the energy so transformed to be wasted in the copper circuits;

(4) The amount of energy to be wasted in the iron circuit;

(5) The maximum induction density to be allowed;

(6) The frequency of the alternations; and thickness of core plates.

We can then calculate—

(1) The lengths, cross-sections, resistances, and number of turns of the primary and secondary circuits;

(2) The length and cross-section of the magnetic circuit;

(3) The waste in the transformer on open circuits;

(4) The approximate primary current on open secondary circuit.

(5) The "drop" in the secondary electromotive force as far as regards the loss in the copper of the secondary circuit.

The designer of a transformer has generally to steer a course between conflicting or opposing conditions of design. He may aim at obtaining some one definite result, or he may try to combine these different conditions so as to obtain the best all-round combination. He may design, for instance, for high efficiency at light loads, regardless of magnitude of magnetising current or of "drop;" or he may aim at a high maximum efficiency and small "secondary drop," and leave the all-day efficiency to take care of itself. Again, it is a distinct advantage in one way for the iron core of a transformer to get hot in working, because it blocks out eddy current loss by lowering the conductivity of the iron, but in another respect it may be very disastrous to the insulation for it so to do.

As far as regards minimising energy losses, the iron core should be run as hot and the copper as cool as possible, and an ideal transformer should therefore have the iron enclosed and the copper ventilated. In the smaller sizes of transformers the iron core losses will always be relatively greater than in larger ones. A transformer for 250 watts (5-light) can hardly be made to lose less than 20 watts in the core, but a 500-watt transformer can be made to lose not more than 25 watts, and a 2,000 watt not more than 45 watts. Hence, supposing that in each case the loss in the copper is 2 per cent., we shall find the full load efficiencies come out respectively 90, 95, and 95·7 per cent., larger sizes being similarly still more efficient.

With respect to magnetising current we have seen that for closed circuit transformers a large magnetising current means proportionate loss in the core. The magnetising current can be reduced by increasing the number of primary turns; but then the secondary turns, and hence the secondary ohmic drop, is likewise increased. The only way in which this last can be then also diminished is by increasing the section of the copper in the secondary circuit, and so again reducing the secondary resistance. This would involve, of course, an increase of cost. In the case of large sub-station transformers it may be worth while to incur this outlay to reduce the copper and iron losses to the lowest possible amount. These may be roughly taken at one watt per pound weight for the iron core, and between four and five watts per pound weight for the copper when the current density is taken at 1,500 amperes per square inch.

The best ratio of iron to copper loss can only be found by trial. Generally speaking, we may say that a high "all-day" efficiency cannot be obtained unless the iron losses are kept small. Hence some designers have sought for the solution of a high "all-day" efficiency by employing open iron circuit transformers. In so doing, however, they meet with another

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difficulty, viz., that they then encounter a large magnetising current. It is true that this current is a current having a small power factor, or is a "wattless" current when in the transformer; but it is not "wattless" in the mains and armature circuits, and a large "magnetising current" means, therefore, an increased loss in transmission, and a lowered plant efficiency. Condensers in parallel with the transformer have then been proposed as a means of extricating the open-circuit transformer from this difficulty. It is pretty clear, however, that all dielectrics possess some hysteresis, and Mr. Steinmetz has shown (see *The Electrician*, April 8, p. 602) that this dielectric hysteresis increases as the square of the electromotive force. Hence, if this is the case, unless we can find a dielectric which will bear working at 1,000 or 2,000 volts with negligible hysteresis, it may happen that the energy loss is merely shifted from one place to the other, and that a closed iron circuit transformer with magnetic hysteresis and small magnetising current is as good or better than an open iron circuit transformer with large "wattless" magnetising current, *plus* a condenser having some dielectric hysteresis working with it. We may avoid Scylla but fall upon Charybdis. There is room for more investigation before these points are settled.

TRACTION.

BY E T. CARTER.

The forces which come into operation in starting and maintaining in motion any vehicle, such as a tramcar, are inertia, friction and weight. The condition of equilibrium at any instant, whether the car be starting, stopping, or moving at a uniform rate, is that the total effort exerted in the direction of motion is equal to the sum of the resistances due to these three causes. Inertia resistance is measured as the product of the mass set in motion into the acceleration, and is therefore only of the nature of a resistance during the time the motion is being increased. While the car has a uniform motion no effort is required to overcome the inertia; and when the car is slowing down the effect of inertia is directly an effort in the direction of motion, and not a resistance. Friction is a force that is always in the opposite direction to the motion, and is therefore a positive resistance, whether the car be starting, slowing down, or maintaining a constant speed. The effort required to overcome this force depends upon the nature of the road or track, the conditions of lubrication of the axleboxes, the speed, and to a certain extent upon the gradient. Windage—a form of friction—depends upon the relative direction and velocity of the wind and car, varying as the square of the component of its velocity along the track. For moderate speeds, such as are met with in tramway work, the variations of road or rail friction with the speed and gradient are usually neglected, the effort required to overcome this friction being nearly the same at all speeds and along all moderate gradients. The following are some of the values for the effort required to overcome the friction of the track alone, on different kinds of track :—

	lbs. per ton.
Granite pavement	17·41
Wood pavement	41·60
Well-worn macadam	44·48
New macadam	101·09
Tramway (clean, wet)	15·00
„ (ordinary)	25·00
„ (very dusty)	60·00

These figures are reliable for speeds not exceeding six miles an hour; for greater speeds a considerable addition must be made on account of windage, the actual amount of which will depend upon the shape and beam of the car, and on the square of the velocity.

Weight comes into action as a resistance in an ascending gradient, as an effort assisting motion in a descending gradient, and is of no account on a level track. The amount of effort required to overcome the weight on a gradient is equal to the product of the weight into the sine of the angle of the gradient.

Collecting these three forms of resistance into one mathematical form, we may write—

$$E = 70.W\alpha + f.W + 2{,}240\,W.\sin\phi.$$

Where E is the total effort required in lbs.,

W is the weight in tons,

α is the acceleration in feet and seconds,

f is the frictional resistance per ton,

$\sin\phi$ is the gradient, expressed as 1 in so many feet.

From this it will be seen that a considerably greater effort is required at starting than on any other part of the run, especially if the start is made on an up-gradient. Taking the case of an ordinary tram line, a car weighing 10 tons would require an effort of about 250lb. to run it at a constant speed of, say, six miles an hour; and this would represent a useful H.P. of about 4. But if this car is required to start from rest, attaining this speed in a space of 50ft., the average acceleration will be 0·8ft. per second, involving an effort of 810lb., and a useful power of nearly 6 H.P. It is probable that at the instant of starting from rest the effort will be double the average figure during the acceleration. This would amount to 1,620lb. for an instant; but the speed being very low there would be only a small H.P. usefully employed. The figures would be even greater than those given above if the case of a car starting on a gradient is considered.

In electric traction the motor H.P. or E H.P. required to run a car does not stand in any constant ratio to the useful H.P., because the motor is, at starting, required to exert a very large effort under conditions in which its efficiency is very low. If we assume, what is very nearly correct, that the effort exerted by the motor as a torque on the driving spindle is proportional to the current in the armature, then it is evident that in the above case the current during the time the car is getting up speed will be about 3¼ times that required to run the car at six miles an hour, while at the very moment of starting it will probably be 6½ times as much. It will be remembered that this current is fed off supply cables or rails at constant voltage, since it is quite impossible to reduce the voltage of the mains at the moment of starting, when there are several cars on the same conductors. So that the figures which represent relative current and effort also represent the relative H.P. supplied to the motor, *i.e.*, while getting up speed the average E.H.P. is about 3¼ times the running H.P., and the maximum E.H.P. is about 7 times, although only a very small fraction of this power is required to move the car.

HIGH-PRESSURE DISCHARGES.

The accompanying illustration has been engraved from a photograph of a high-pressure discharge between two terminals separated by a glass plate, being one of the experiments shown by Messrs. Siemens Bros., at the Crystal Palace Exhibition. The current was produced by a Siemens' alternator, capable of giving a maximum output of 500 amperes, under a pressure of 80 volts. The alternator has 20 poles, and ran at a speed of 400 revolutions per minute, thus giving a frequency of 66⅔ complete periods per second. The current passed through the primary of a "cable" transformer, whereby the output was converted from 500 amperes × 80 volts to 15 amperes × 2,500 volts. The secondary of the "cable" transformer was joined by a concentric cable, about 200ft. long, to the primary of a triple-core transformer, the secondary of which gave ½ ampere × 50,000 volts. This is only one quarter of its total capacity, which is 2 amperes × 50,000 volts.

The glass sheets used were 2ft. square, and from ⅛th to $\frac{3}{16}$th-in. thick; the two brass disc electrodes were 3½in. in diameter, and were placed centrally on opposite sides of the sheet of glass and touching it; they were joined up directly to the secondary terminals of the transformer, and no spark gap was used, as in the experiments of Tesla, Elihu Thomson, and others. By regulating the exciting current of the field of the alternator the pressure was gradually raised from 20,000

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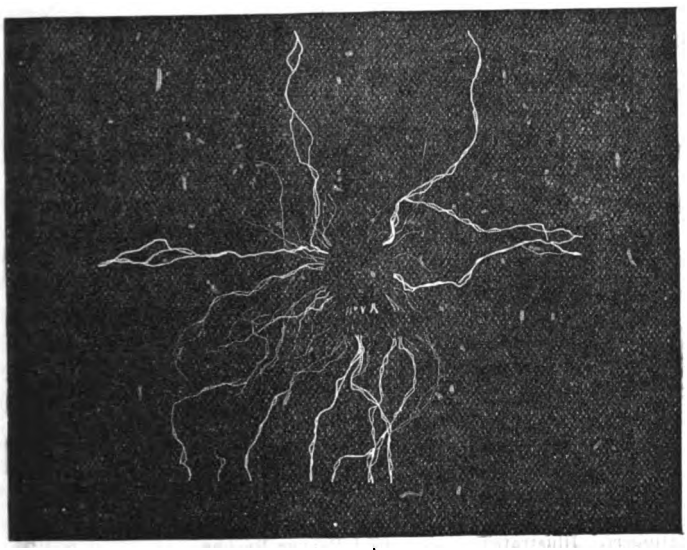
volts to 40,000 volts or 45,000 volts. The photograph was taken at about 45,000 volts. From the experience gained from two months' work, it is possible to foretell that with a $\frac{3}{16}$th-in. sheet the brilliant flashes will occur at about 40,000 volts, while with a $\frac{1}{8}$th-in. sheet they may begin at 35,000 volts or even lower. An electro-dynamometer joined up in the circuit before the glass plate did not show any indication of a current passing, though $\frac{1}{10}$th ampere should have given a deflection of 25 divisions. Calculated from the current in the alternator circuit, which averages 100 amperes just before the sheet of glass is pierced, the current in the high-pressure circuit would not exceed $\frac{1}{10}$th ampere, and is probably very much less.



Discharge between two electrodes, 3½in. diameter, separated by a sheet of glass 2ft. square.

THE CULTIVATION AND COLLECTION OF GUTTA-PERCHA.

At a meeting of the Société d'Encouragement in April last, M. Sérullas gave a summary of the results of his latest expedition. The gutta-percha question is, in M. Sérullas' opinion, a serious one, and a grave crisis can only be avoided by methodical cultivation and thorough utilisation of existing resources.

The present mode of collection, he said, only made use at long intervals of mature trees. In May, 1888, M. Jungfleisch suggested to him that gutta-percha might be extracted from the leaves. The outcome of this suggestion was that leaves picked in Malay had been sent home to M. Jungfleisch and treated in the laboratory by an entirely new process, with results as decisive as they were unexpected. Not only did the extraction of the gutta-percha from the leaves prove extremely economical, but the yield was enormous, By this process every *isonandra* with leaves became *ipso facto* workable. One could obtain without touching the trunk a pure dried gutta-percha, amounting in weight to 8 to 9 per cent. of the raw material after the latter had been desiccated in a stove at 100° C. In future shrubs as well as decaying trees would be utilisable.

So long as the solution of this question was a process requiring a long time it was condemned to remain a Government one. Henceforth, an outlet was afforded for private enterprise. The plantations which might be undertaken and those which were being undertaken by Government would be workable after a short lapse of time; and until these were available French capital could make the utilisation of the last resources of the Malay forests the object of a vast undertaking, capable of procuring for it great and immediate profits.

Could a French Company procure in the heart of the savage regions of the Malay Peninsula raw material in sufficient quantity for immediate commercial and industrial operations? Undoubtedly! If they took no notice of the fantastic, but nevertheless truthful figures which had been published, and if they reduced as a flagrant exaggeration the figures relating to gutta-percha importations since 1843, and only considered undoubtedly genuine gums, they obtained the figure of decidedly more than one and a-half million for the number of their still existing vegetable progenitors. In the period of 48 years, from 1843 to 1891, the electrical industry alone had consumed more than 4,700,000 kg. of gums, which certainly came from the *isorandra percha*. By tapping the felled trunk an *isonandra* of from 12 to 15 years of age would only yield 90 to 110 grammes of impure moist gutta; it was impossible for a tree of 30 years to furnish more than from 250 to 260 grammes. At no period of its existence did the yield of a tree, under the native treatment, exceed 500 grammes. After having given this maximum the tree declined, and finally the exudation of the milk from incisions made in the trunk became next to nothing. In 48 years the same tree could only have been cut four times. Assuming that at the first cut every tree was at its best, it was evident that it could not have supplied by to-day more than 500+330=830 grammes of gutta. The production of 4,700,000 kg. therefore required the tapping of more than 5,600,000 separate trees. Local statistics and actual exports agreed with these figures, and pointed to the existence of more than one-third of these trees, say, at least, 1,850,000. These trees, it was true, had not long to live, and their exhaustion was beginning to render them for the most part of no good to the native. But if a vigorous adult tree was able to furnish without inconvenience every six months, and during a certain number of years, 1½ pecul* of dry leaves, the foliage of a tree already attacked by decay certainly did not weigh less than 1 pecul. A young tree of four or five years never had less than 2.9 to 3 kg. of leaves (weight taken after desiccation in a stove). The leaves of young trees and those of a recent growth were notably larger and somewhat richer in coagulated milk than the leaves of big trees. Moreover, the lopping of the branches, which were few at that period, considerably increased their number. It was very easy to make the *isonandra* grow in pollards. From a tree valueless to a native, that was to say too old to lend itself to trunk working, it was easy to gather leaves capable of yielding 4 kg. of gutta-percha. In one single day, and confining their operations to a tree of that description, they could extract five times as much gutta as the natives had succeeded in obtaining in half a century. A young tree of four or five years could by merely plucking all its leaves furnish a minimum of 261 grammes of gum; that was to say, just as much as a tree of thirty years was capable of giving when the trunk was sacrificed.

In short, there existed in the Malay forests more than 1,500,000 *isonandra percha*, soon to be lost for ever, and already beginning to be of no good to the natives, which contained within their organism more than 6,000,000 kilogrammes of gutta-percha. Assuming that the leaves which were picked were not replaced by fresh ones, there was here a more than satisfactory margin for a safe enterprise.

* 1 pecul = 62·5 kg. = 135·631lbs.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, May 20th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Electro-Metallurgy." By J. Wilson Swan, M.A.

TUESDAY, May 24th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "The Measurement of High Temperatures." By Prof. W. C. Roberts-Austen, F.R.S. The last ballot for members for the session will be taken at this Meeting, which will be adjourned at 9.30 p.m., when the President and Council will hold a Reception in the Libraries.

SOCIETY OF ARTS.

8 p.m. Foreign and Colonial Section. Paper to be read: "The Extension of Colonial Trade." By Colonel Howard Vincent, M.P.

WEDNESDAY, May 25th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Researches in Photochromy." By F. E. Ives.

THURSDAY, May 26th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

FRIDAY, May 27th.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Paper to be read: "On the Present State of our Knowledge of the Connection between Ether and Matter.—An Historical Summary." By Prof. O. J. Lodge, F.R.S.

OLD STUDENTS' ASSOCIATION.

7.30 p.m. Smoking Concert at Masons' Hall Tavern.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Emotional Expression." By Sir James Crichton-Brown, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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ALTERNATE CURRENT DIFFICULTIES.

Alternating and continuous current supply are not yet on equal competing terms. The former is still handicapped by a mass of complications, and many an engineer declines to face the mathematical intricacies of the subject, excusing himself on the ground that high pressures are dangerous and unnecessary. The exponents of the alternate-current system have only themselves to thank for the present state of this branch of electrical engineering; some of them are rather fond of mysteries, and few have the power of expressing themselves in attractive language. If steam-engine construction had begun with thermodynamics, in the same way that alternate-current work has started on a strictly scientific basis, there would have been a general impression that without a thorough understanding of $p\,v^{1.1}$, no one should dare to use steam expansively; and without full knowledge of BOYLE'S law, hyperbolic logarithms, and absolute temperature, no one should pretend to measure steam consumption. Steam engine-builders began in happy ignorance of all these things, and in a less degree the same course was followed at first in alternate-current work. But the conditions were soon altered, and no two electrical engineers are to be found who can agree on the best way of measuring the power taken by a transformer, or who hold the same views about those various losses by hysteresis, eddy currents, magnetising currents, &c., which have no parallel in continuous-current work. And yet it appears that if any one can but hold up a theory, however

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unintelligible, and stick to it, he thinks he has a right to rank among alternate-current workers; while the plain continuous-current man, who says that he is an amateur in all this, is regarded as of a lower order altogether, and if he uses an alternator and a few transformers for practical work, and does not pretend to an opinion on the relative merits of FOURIER'S theorem and exponential functions, he is in danger of being considered a spy.

One of the most complicated branches of the subject to a beginner is that of measuring the energy given out by a dynamo or absorbed by a transformer. Split dynamometers, triple voltmeters, triple ammeters, compensated wattmeters, electrostatic wattmeters, have their advocates and their opponents. If an attempt be made to measure the output of a dynamo, careful consideration must be given to the disposing of the waste energy; iron wire coils are treacherous, and a water tank is not above suspicion. The veriest tyro knows that he must not multiply volts and amperes together and expect to get the energy given out by a supply station; and yet, in reckoning up his efficiency, he has to take something more into consideration than the true energy supplied to the transformers as measured by split or triple instruments.

The continuous-current man reads off on a meter the output of his station, or figures it out with ease from the log sheet; he knows his fall of volts, and takes the indications of his pilot wires with confidence; all the amperes he sends out get through the lamps and so home again, unless bad leaks are tolerated. But no such easy lot falls to the alternate-current engineer. His volts are his first trouble; he cannot measure them direct on a CARDEW or magnetic voltmeter, for even hundredths of amperes are expensive at 2,000 volts. He is warned that he cannot depend on the ratio of transformation if he tries to "step down," and he waits before he orders an electrostatic voltmeter until someone else has used one, until he knows how it has been calibrated, and whether it will short circuit if he sneezes in the same room with it. At the worst, he can use his engine-room lamps as an indication. When he comes to measure his amperes, he is told that certain ammeters are only correct for a particular frequency, in fact they are only correct when they are correct, and at other times it is not safe to apply a correction as could be done to Capt. CUTTLE'S watch. When he has got his amperes he may not multiply them by his volts. He may choose between FERRARIS, BLAKESLEY, AYRTON and SUMPNER, FLEMING, and SWINBURNE, for a method of measuring the true energy delivered; but when he comes to consider his coal bill he finds that he is sending something else out of his station. The true watts are only what he gives to the transformers, and the wattmeters take no account of the lagging, spurious, or watt-less amperes. To find the C^2R losses he must measure the amperes independently, and knowing the resistance of the mains, add the loss to the energy delivered. No observations of this kind have yet been published, but then no coal bill of an alternate-current supply station has yet appeared on which it has been possible to base any deductions.

Considering how little HUME'S "plain man" or BERKELEY'S "thinking gentleman" can understand about alternating-current work, it is a marvel that it runs continuous currents so close. Only quite recently transformer men, after being taunted about heavy coal bills, suddenly admitted that the present system was wasteful and temporary, and that sub-stations will knock off 20 per cent. or so of present losses. We should not be surprised to see an almost unanimous change in favour of inductor dynamos, and an equally important revolution might be effected by the adoption of condensers for supply work. Alternating currents are occupying the attention of some of the best men, and great success is meeting their endeavours; but the mathematical jargon of the subject still repels many others equally good, and will continue to do so until a clear distinction has been made between lecture-room work and shop work in this particular branch.

OBITUARY.

EUGENE H. COWLES.

We regret to have to record the death of Mr. Eugene H. Cowles, who died at El Paso, Tex., on April 21st, at the early age of 38. Mr. E. H. Cowles had attained a world-wide recognition by the scientific world for his inventions in connection with the manufacture of aluminium. These inventions, in the origination and development of which he was assisted by his brother, Mr. Albert H. Cowles, involved in principle the application of the heating action of the electric current for the reduction of aluminium and other metals. Mr. Cowles was also connected in the engineering world with the invention of the trolley system.

Mr. Cowles, who was born in Cleveland, O., began his career as a reporter for the *Cleveland Leader*, of which his father was editor. After two years he, however, turned his attention to civil engineering, and very soon became interested in the production of aluminium. A small plant was erected at Cleveland, O., by the Cowles Brothers, where they invented the well-known Cowles process, out of which have grown the large aluminium works at Lockport, N.Y., and the Cowles Aluminium Company of the United States and Great Britain. The result of this invention was a revolution in the aluminium industry as profound as that caused by the earlier work of Deville. To carry out their process effectively, the Messrs. Cowles were compelled to do a large amount of pioneer workin connection with the design of dynamos of large power, the control of currents of hitherto unprecedented magnitude, the manufacture of carbon electrodes of great size, and to work out, in the face of many difficulties and discouragements, many details of operation that now seem comparatively easy, but for which at that time there were no precedents to build upon.

The first institution of learning to take note of, and to recognise the importance of the inventions of the Cowles Brothers, was the Franklin Institute, to the *Journal* of which we are indebted for most of these particulars. Shortly after the first public announcement of the Cowles process, an invitation was extended to the inventors to read a Paper on the subject before the Institute. This Paper was presented at the meeting held January 20, 1886, and, under the title, "The Production of Aluminium and its Alloys in the Electric Furnace," appeared in the *Journal* for February, 1886. It was an able and comprehensive treatment of the subject, and reflected the highest credit on its author. The success with which the efforts of the inventors to secure the general adoption of their process was crowned, sufficiently demonstrated that their faith in its commercial and technical value was neither misplaced nor exaggerated. The Franklin Institute, in recognition of the merits of the invention of the Cowles Brothers, awarded to them in 1886 the highest honour in its gift—the Elliott-Cresson medal—"for their invention of a new process in the metallurgical arts for the reduction of refractory substances," and recommended the award of the John Scott Legacy Medal and Premium to the inventors, "for their electric smelting furnace," which recommendation was subsequently confirmed by the Board of Directors of City Trusts. Subsequent events demonstrated that the judgment of the Institute in estimating the value of these inventions so highly was fully justified.

His untimely death, says "W. H. W.," in the *Journal* of the Franklin Institute, before he had yet reached the measure of years when those better equipped with physical endowments are in the prime of their powers for usefulness, is a loss which all friends of science will learn with sincere regret.

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REVIEWS.

Prof. Hertz's Researches on the Propagation of Electric Force.
(Untersuchungen über die Ausbreitung der elektrischen Kraft. Dr. H. Hertz. Leipsic: J. A. Barth, 1892).

At some time or other every electrician has been questioned as to the nature of electricity, and has had to return an unsatisfactory answer. So the majority of us, even those almost entirely engaged with its practical applications, have endeavoured to read and understand the present-day theories of electricity, and more especially to make ourselves acquainted with experiments bearing upon them. This being the case, Prof. Hertz needs no further introduction. As an experimenter of the first rank his name is already familiar to English electricians, and all will be glad to learn that he has found time to edit the volume of his collected papers which is now before us. The book has been enriched by two very interesting chapters, the first giving an historical account of Prof. Hertz's work, while the various theories of electric phenomena are reviewed in the second one. The author has also included in the work a forgotten paper of von Bezold, written more than twenty years ago, in which some of his own results are anticipated. As these results were obtained in a manner quite different from that of Hertz, their truth is strikingly confirmed by the agreement of the two independent methods.

We learn from the introductory chapter that Prof. Hertz was first attracted to the subject of electric waves by von Helmholtz, who called his attention to a prize offered by the Berlin Academy for a research on an experimental relation between electrodynamic forces and the dielectric polarisation of insulators. Helmholtz and Feddersen had already investigated under what conditions the discharge of a Leyden jar might give rise to an oscillatory electric current, and Hertz hoped to extend their researches. He tells us, however, that at this stage he considered such electric motions far too irregular and violent to be made use of, and it was not until 1886, at Karlsruhe, that clear evidences of simple oscillations in metallic circuits were obtained. A more powerful effect was produced by oppositely charging two conductors separated by a wire containing a spark gap; these conductors on discharging into each other through the wire, gave rise to waves of fairly definite period which were propagated to a considerable distance. With this discovery Hertz began his remarkable series of researches by which he succeeded in establishing that these electrical motions do not merely directly affect bodies at a distance, but, on the contrary, are transmitted by some medium filling all space; that this medium has properties similar to those of the ether which transmits the vibrations of light; and, finally, that the velocity with which waves travel through the medium is equal to the velocity of light. He also showed that ultra-violet light can so influence a dielectric as to make the passage of sparks across it more easy. It requires no further evidence to enforce the conviction that electricity and light are manifestations of one and the same medium. Maxwell had previously arrived at the same conclusion from purely theoretical considerations, namely, by comparing the mathematical equations of the propagation of electric disturbances through a medium with the corresponding equations in the case of light. The quantity which in the electrical equations is the analogue of the velocity of light was experimentally found by several observers to have the same value as the latter, and hence Maxwell concluded that both classes of disturbance were transmitted by the same medium. Hertz thus established by experiment what Maxwell had indicated from theory, and we now know that the difference between an electric wave and a light wave is one of length alone.

It would be quite impossible within the limits of a review to give any adequate description of the methods used by the author in his researches. Fortunately this is rendered unnecessary by the translations of the more important of Prof. Hertz's Papers, which Mr. G. W. de Tunzelmann prepared for readers of this journal (vide *The Electrician*, Vol. XXI., p. 587, *et seq.*). Translations of other Papers included in the present volume will be found in *Nature*, Vol. XXXIX., 1888-89, and in the *Philosophical Magazine* for 1889. The work of von Bezold, however, although of extreme interest, does not appear to have been hitherto published in the form of an English translation. He allowed an electrical machine to send sparks to a knob connected to earth partly through the secondary wire of an induction, and partly by another bye-path containing two metallic points with variable lengths of wire between them. The points were parallel to each other, and faced a glass plate resting on tinfoil, this latter being connected to earth. On charging the points the electricity leaked from them to the surface of the glass, thus electrifying it, and on scattering a light powder over the glass figures were formed (Lichtenberg's figures), whose shape was quite different, according as the point was positively or negatively electrified. When the bye-path had its two points close together the figures were the same for each, but on inserting a sufficient length of wire between them the one gave a positive and the other a negative figure. In this way Herr von Bezold marked off the nodes and loops of the vibration sent along the bye-path and reflected at its far end, and he measured the wave length. In many respects the results are similar to those obtained later by Dr. Lodge in his experiments with lightning conductors.

In the chapter on electrical theories Prof. Hertz points out an apparent inconsistency in Maxwell's theory of dielectric polarisation, which leads to very confused notions concerning the nature of electric charge. The theories of action at a distance all assume electricity to be something analogous to matter, which can be added to or taken away from a conductor, and which exerts forces of attraction or repulsion. Maxwell, on the other hand, regards an electric charge as simply produced by the sudden change of polarisation at the boundaries of a dielectric. A charge is therefore looked upon not so much as a property of the conductor as of the boundary of the dielectric in which the conductor is placed. This idea is seen more clearly in the case of magnetism. An iron bar is supposed to consist of particles, each of which is a small magnet. On magnetising the bar these particles are polarised, and turn so that their north poles all point in the same direction. We then have along the length of the bar a chain of particles with a free north pole at one end and a free south pole at the other. In the intermediate portions a north always faces a south pole, so that there is no free magnetism except at the ends. In the same way, the particles of a polarised dielectric have opposite (*i.e.*, + and −) properties on their opposite faces. In the interior of the dielectric these destroy each other, but at the ends they give rise to the phenomenon of electric charge. The apparent inconsistency referred to arises from the fact that Maxwell seems to regard a charge from the point of view of the "action at a distance" theories, as soon as he ceases to be immediately concerned with questions involving the consideration of the surrounding medium; for instance, in the cases of current electricity and electro-chemistry. That the medium does play an important part is seen when we recollect that only the superficial parts of a cable are effective in transmitting power by alternating currents—a fact for the proof of which both Hertz and Lodge have devised several most instructive experiments.

We venture to hope that the greatest stumbling-block to the spread of a knowledge of Prof. Hertz's work will speedily be removed, and that a translation of the present volume of collected Papers will soon be forthcoming. J. L. Howard.

THE BRADFORD ELECTRICAL TRAMCAR.

According to the promise made a fortnight ago, we illustrate by the accompanying engraving, the under frame of the electrical tramcar at Bradford. The motors and gear have been constructed by Messrs. Easton and Anderson, of Erith. The body of the car was built by the Lancashire Waggon Company. The wheels are 28in. in diameter and have a 5ft. 10in. base on rails of 4ft. gauge. The restriction of the wheel base is always a great difficulty in electric traction; and when the cars are large enough to necessitate the use of bogies, the difficulties are increased rather than diminished, for the motors have still to be packed away between the pairs of wheels. The car at Bradford, which, as we have observed on a former occasion,

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has to compete with steam and not with horses, is probably as large as is profitable to run, having seats for 36 passengers. This car, having been built to demonstrate the suitability of electric traction for the extremely difficult conditions which are to be found at Bradford, Mr. Holroyd Smith has done wisely in providing very ample power; and the result has proved that even on the steep hill and curve, and with an over-loaded car, he can easily run and even stop and start if needed.

Owing to the rather large motors and limited space, it has been found necessary to incline the shafts slightly, the arrangement recalling a former design of Mr. Holroyd Smith, in which a worm was provided at each end of the shaft, one working above and the other below the driving axles, thus neutralising the thrust. Ball bearings are provided for the thrust collars of the present arrangement, and contribute, no doubt, in reducing part of the friction, which has always been so great an objection to the use of worm gear. A fairly fine pitch is, of course, desirable on grounds of mechanical efficiency; but with such a gear the car would be immovable, unless under current. Mr. Reckenzaun has used a long-pitch screw to allow the car to be pushed, and to run down hill freely; and Mr. Holroyd Smith has given special attention to the details of the threads and the shape of the teeth. The worms in the present example have three threads of 4½in. pitch. The worm wheel has, therefore, a pitch of 1½in., and has 34 teeth. The ratio of the gear is 11 to 1. One of the worms is shown in the side elevation, Fig. 1. The gear is completely boxed in, and runs in oil.

The arrangement of two armatures between a single pair of magnets has been employed before for various purposes, and is called a "dual motor" by Mr. Holroyd Smith. The armatures are 12¼in. in diameter, and are 11in. long. We understand that with a test on a brake, the motors and gear gave the remarkably good combined efficiency of 65 per cent., considerably better than might have been expected from the worm gear alone. The weight of the under-frame, with the two dual motors, gearing, axles, wheels, brakes, &c., is 4½ tons. The total weight of the car with fittings is 6½ tons. The brakes, switches, trolley-rod mounting, and other details have been worked out with great ingenuity.

The object of using so many motors was to overcome the difficulty of starting, and to enable a powerful effort to be exerted when climbing the gradient. We alluded on a recent occasion to some of the different methods which have been employed for this purpose. The torque being proportional to the current only; current alone, and no volts, may be said to be needed at starting. When the motor begins to run it generates back-volts, and electrical pressure is then needed, but only in proportion to the speed. In accumulator traction the large current, as well as the reduced pressure, is easily secured by coupling the batteries in parallel sets; but with conductor lines as at Bradford no change can be made in the volts, unless by wasting them on resistances. The double set of dual motors is the reverse arrangement, achieving much the same end, but at considerable cost and increase of weight, together with some loss of efficiency. There are three ways of arranging the armatures, and these are shown in Fig. 2. A resistance switch is provided for turning on the current gradually, and for minor regulation of speed. The four armatures are used

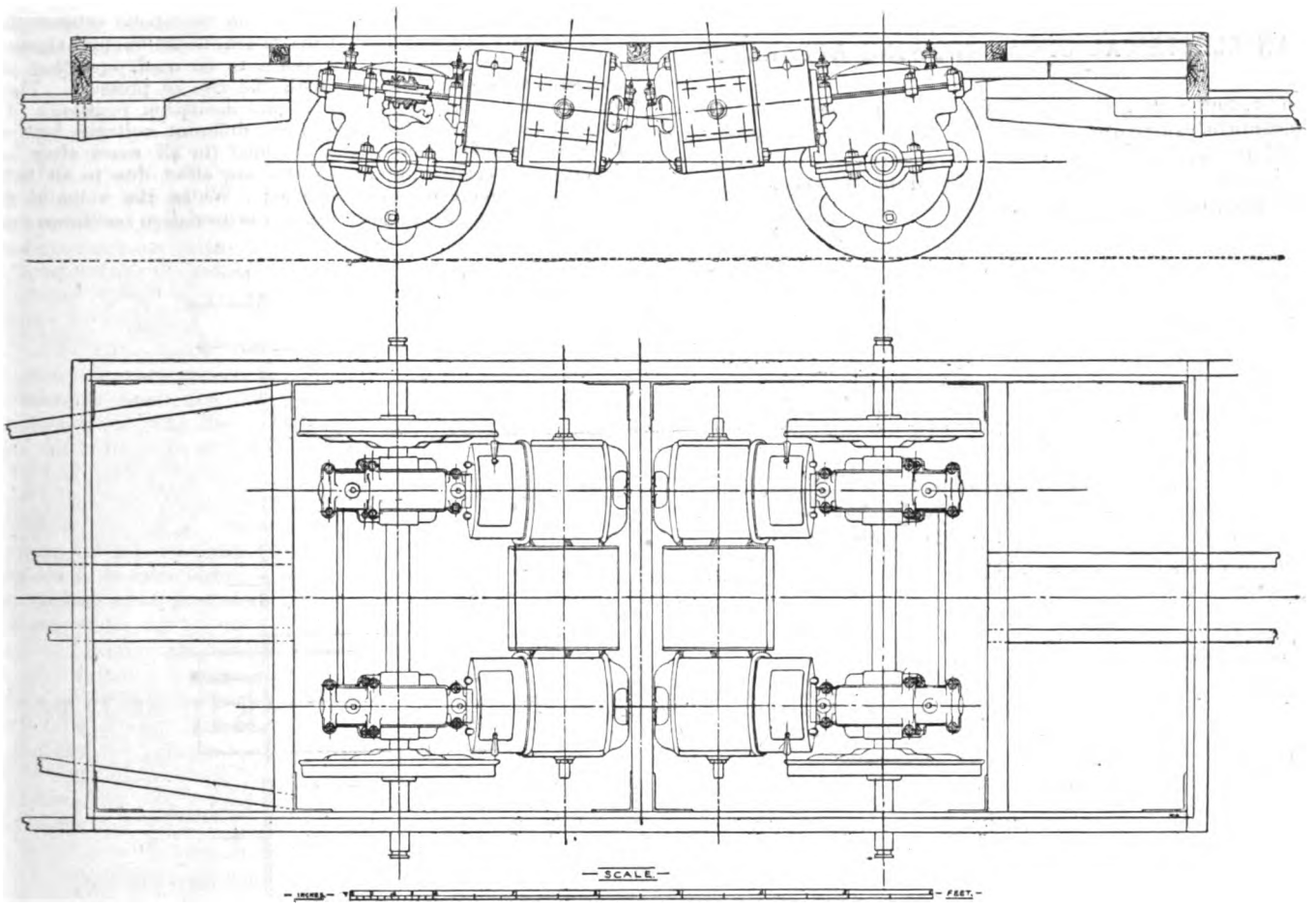

FIG. 1.—Side elevation and plan of under-frame.

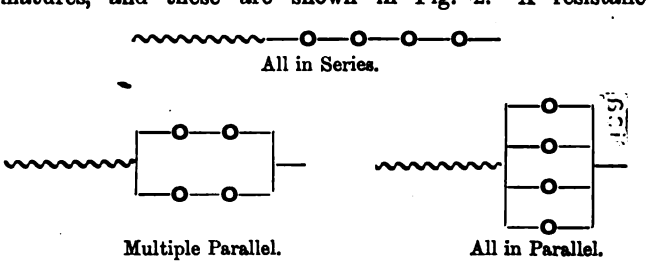

FIG. 2.—Arrangement of Motors in Series and Parallel.
Resistance. O, Armatures.

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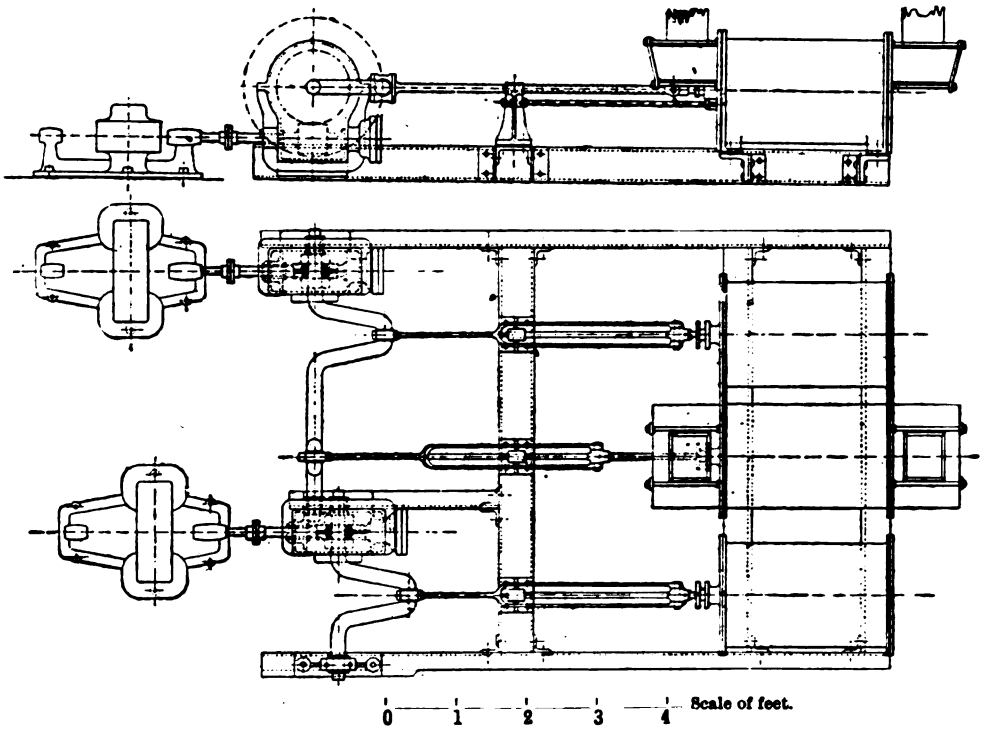
in series for ordinary running. To the dual arrangement Mr. Holroyd Smith applies the name "multiple parallel," which, unfortunately, conveys no meaning whatever to the uninitiated. This is used for heavy work or for occasional easy starting, and the complete parallel connection is reserved for the heaviest starting, being more than sufficient to run the loaded car up the 1 in 14½ gradient.

In order that the car may run freely round the curves, the wheels are not keyed together on the axles. Two wheels at opposite diagonal corners are keyed to the axles, the right-hand wheel at one end, and the left-hand wheel at the other being so fixed, and the worm wheels next to these wheels are also keyed direct to the axles. The other worm wheels are keyed to sleeves, which drive the remaining car wheels.

AN ELECTRICAL ORGAN-BLOWING APPARATUS.

The new organ erected in the large Concert Hall in the Goldsmiths' Institute, New Cross, containing 60 stops and 3,107 pipes, is blown by means of electricity, the apparatus having been designed and constructed by Messrs. Easton and Anderson, of Erith Iron Works.



Side elevation and plan of Electric Organ Blower.

The gear (*see* figure) consists of three cast-iron blowing cylinders, 17in. diameter and 24in. stroke, placed side by side on a framework made of rolled joists, secured to the concrete floor of the blowing chamber, which is situated at one end of the gymnasium. Two of these cylinders supply one regulating reservoir with wind at 5in. pressure, and the third cylinder supplies a second with wind at 10in. pressure, from which suitable trunks are led to the organ. The pistons of the two low-pressure cylinders are worked by a double-throw crankshaft, driven by a worm and worm-wheel, which is enclosed in a cast-iron casing, the worm being connected by a coupling with the spindle of the motor, which is capable of giving out ordinarily about 2½ H.P. The piston of the third cylinder is worked by a single-throw crank-shaft, with a similar worm gear and another motor of the same size. The motors always run at an approximately constant speed; and when the reservoirs are full, automatic bye-passes are opened between the ends of the cylinders, and the air is simply passed backwards and forwards until the reservoirs fall again and shut the bye-pass. Switches are arranged with suitable resistances close to the organ keyboard, by which either or both of the motors can be started, and which also provide a means of, to some extent, regulating the speed. The generating dynamo is driven by a countershaft and belts from the workshop shafting. It is capable of giving an output of about 100 volts and 50 amperes.

NOTES ON MR. W. H. PREECE'S PAPER ON "SPECIFICATIONS FOR INSULATED CABLES."*

BY C. HEIM.

It is stated in Mr. Preece's Paper on the above subject that it is frequently assumed that the insulation should be approximately proportional to the potential difference to be used, and that the exactness of the test increases with the rise of pressure. There follows then a number of values for the insulation resistance of a gutta-percha core, obtained from using different voltages between 14 volts and 560. The values obtained (in all cases after one minute's electrification) do not exhibit any effect due to an influence of the voltage on the insulation. Whilst the volts of the battery were being continually raised, the insulation resistance came out sometimes above and sometimes below the value it had with the lowest voltage.

For my own part, I venture to doubt whether it is practically the case, as Mr. Preece says, that the above assumption is generally made. In Germany, at any rate, it is not so. For instance, will any of my readers maintain that an insulation resistance measured with 50 volts will appear double as large as when 100 volts are used, or that a testing battery of 20 cells will show results only a quarter of those shown by a battery of 5 cells? If anything of this kind at all is generally accepted, it is only that an insulation resistance is found lower when measured with a high pressure than with a low one. Uppenborn was the first to give this fact his attention; Forderreuther and the present writer have proved by tests that there is a fall in the insulation resistance, measured by the ordinary substitution method, when the voltage is increased (see *The Electrician*, Vol. XXV., p. 751). It is hardly possible, so far as results at present obtained go, to give an exact law connecting insulation and voltage even for one material. The reason for this lies in the large number of sources of error which it is exceedingly difficult to eliminate.

* Abstract from the *Elektrotechnische Zeitschrift*.

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Mr. Preece further considers it is sufficient for practical purposes to make use of the figures he gives. The figures, however, refer exclusively to gutta-percha. It would have to be regarded as an important step in the direction of progress if the non-existence of any of the possible variations in this substance could be relied upon. Unhappily, the tables are not provided with any details as to the influence of the two worst sources of error, viz., changes of temperature and the existence of residual charges. The values given for the insulation resistances at different voltages vary by as much as 7 per cent. It is out of the question to attribute such important differences to errors of observation, as for such resistances as those in question (from 100 to 200 megohms) there should not be any difficulty with proper testing arrangements in getting results within 1 per cent. of the true values. There remains, therefore, the possibility either that the temperature did not remain constant between successive measurements or that a sufficient interval of time for the residual charge to become dissipated was not allowed. In all probability both these causes have combined to produce the differences observed.

I have myself made the relation between insulation resistance and voltage, especially for gutta-percha, the subject of a careful examination. The greatest possible care was taken to maintain a constant temperature, and after each two minutes' electrification the copper core was earthed for a considerable time, depending upon the voltage used. Before taking each fresh measurement the existing residual charge was duly measured and allowed for, and every precaution was taken to secure reliability in the results. The conclusion arrived at was that a decrease in insulation resistance undoubtedly takes place when the voltage is raised. This decrease in the case of gutta-percha cables reached 6 6 per cent., whilst the voltage was raised from 50 to 460 volts in the case of electrifications lasting one minute, and 7·1 per cent. when they lasted two minutes. These results are the mean of eight different series of tests, in which the decrease fluctuated somewhat, though it was never under 5 per cent. Whilst the voltage was raised from 50 volts to 200, a decrease in insulation averaging 2 per cent. was observed. Two lead cables, the insulating materials in which were different, showed a similar decrease, though to a smaller extent than in the case of gutta-percha. The insulation resistances of two wires placed on the walls of a room and the field winding of a dynamo, fell off to a more noticeable extent.

From Mr. Preece's remarks, it would appear that he has remained in ignorance of my results although they were reproduced even in many foreign papers. (See *The Electrician*, Vol. XXV., p. 751.) I may add that whilst at the Frankfort Congress last year, Dr. Obach, of Messrs. Siemens Bros., informed me that measurements carried out by his firm on gutta-percha cores corroborated the results of my tests

NOTES ON THE LIGHT OF THE ELECTRIC ARC.

The following is an Abstract of the Discussion on the above Paper, which was read by Mr. A. P. Trotter on April 28th before the Institution of Electrical Engineers :—

DISCUSSION.

Abstracts marked thus (*) have been revised by the speakers.

THURSDAY, APRIL 28TH.

*Mr. SWINBURNE thought that the statement, due in the first place to Prof. S. P. Thompson, that the temperature of the arc was necessarily at that of volatilising carbon, gave us the means of constructing an electrical standard of light. What was wanted was a standard which was definite as to quantity and as to colour. Kirchhoff had shown that all incandescent bodies gave out light of the same colour, that is to say, having the same proportion of rays of different refrangibility. The amount of light given by each square inch at a given temperature depended on the emissivity. It was hardly likely that the emissivities of different kinds of arc carbons varied perceptibly. To get a standard, the image of the arc might be thrown on a screen by a lens, or preferably by a screen with a pinhole of known size. The image is thrown on the screen, the image of the crater being uniformly illuminated at a standard illumination of a standard colour. A second hole also of fixed area in a second screen is arranged in the middle of the image of the arc. Through this hole the standard quantity of light of the standard colour is transmitted. As Mr. Trotter pointed out, the colour of the arc light was practically that of daylight, and was thus the best for a standard. The quantity of light of any particular colour was thus also standardised. It was much to be regretted that Mr. Trotter had not given more information about arc lamps with alternating currents. With the same power it was to be expected that an alternating arc should give less light, as there were two small craters instead of one large one. In addition, one crater was on the wrong carbon. An ordinary alternating lamp also ran with less power, the pressure being lower. On the other hand, an alternating arc lamp was much easier to deal with, as an inductive circuit could be used to secure a steady light, instead of a wasteful resistance. He would like to hear the opinions of those who had had much experience of alternating arc lamps. He had tried passing a stream of gas through a hollow carbon in 1884 or 1885, but it did not increase the light at all ; it merely caused unsteadiness, or blew the arc out. There was a curious discrepancy between the light per square inch of the sun and of an arc. It could hardly be imagined that the sun could be blacker than carbon when cold.

Major-General FESTING, R.E., said that he firmly believed that the light from an electric arc lamp was real white light. He had observed that the arc light was distinctly yellower, but not to any great extent, than diffused daylight. After staying up all night, the sense of yellow light having become wearied, daylight appeared quite as ghastly as ever the electric light appeared to be. The idea of white was the integration of the whole light from the sun and sky. The blue light was not, strictly speaking, absorbed by the atmosphere, but was scattered. In matters of colour no absolute strict law could be laid down ; it could not be said absolutely that anything was white light.

*Dr. SUMPNER said that the explanation of the shape of the characteristic curve of the arc light practically proved that it was due to the fact that the incandescent surface of the carbon gave out light in any direction proportional to the apparent area of the surface seen from that direction. This was confirmed by a formula given at the Paris Exhibition in 1881, viz. :—The mean spherical candle-power was equal to half the horizontal candle-power, *plus* a quarter of the maximum candle-power. This could be explained by assuming that the characteristic curve was made up of two parts—the chief one being due to light emitted from the crater, considered as a bright horizontal disc, the other due to the more or less incandescent sides of the carbon.

*Mr. MORDEY said that he had never come across a uniform horizontal crater, he had always found them quite concave. It was stated that in the case of cored carbons the cored part was less brilliant than the rest of the crater, and he gathered that Mr. Trotter intended them to understand that the core was made of something other than carbon. He believed some makers now used certain substances not carbon ; but a good many carbons were made with simply soft graphite for cores, and in such carbons the arc was steadier, and there was no difference in the density, in the colour, in the degree of light over the crater. At the Naval Exhibition they had all admired the very large arc run on the lighthouse. It was visible over the whole of London, and seemed to burn very steadily whenever he saw it. That was an alternating current arc, and it certainly was steadier than any large direct current arc he had ever seen. In direct current search-lights they knew how difficult it was to get steadiness without a large steadying resistance in the circuit. With regard to alternating-current arcs, he entirely disagreed with the author of the Paper as to their being generally unsatisfactory and giving trouble. He had got better results with alternating currents than with direct and he put it down to the fact that first, they could use longer arcs with the same E.M.F. ; and the small difference of length, due to the feed, did not so affect the whole result of the arc as with the short direct current arc ; and secondly, to the fact that the alternating current caused a slight vibration in the mechanism of the lamp, and that assisted the feeding of the carbons. He quite agreed with Mr. Trotter's criticism of the lighthouse arc shown on the wall. He thought that was a very bad arc indeed ; the arc was far too short, the light could not get out. He thought there should be a length of clear arc, at least one quarter of the diameter of the carbons, to get good results. His company would have running a very large alternate-current arc lamp at the Crystal Palace Exhibition, taking about 200 amperes, automatically fed, and they would have the opportunity of seeing whether that lamp could be made as steady as an ordinary search light arc. He did not quite understand whether the arc could change its temperature during half a period of the generation of an alternating current. He thought that with any ordinary rate of alternation the mass of the carbon would be too great to allow of any fluctuation in temperature. It must surely act as a kind of thermal fly-wheel and have a fixed temperature during the whole period. With regard to the custom of the trade in calling a 10-ampere 50-volt lamp a 2,000 c.p. lamp, he thought they had high scientific authority. At the Paris Exhibition, or perhaps it was at the last Crystal Palace Exhibition in 1882, a committee containing, so far as he remembered, the President and several other scientific people, made some photometric measurements of the Brush arc lamp and brought it out at 2,300 c.p., and ever since then, as they had not altered the lamp, they had felt perfectly justified in describing it as a 2,000 c.p. lamp.

THURSDAY, MAY 12TH.

*Dr. FLEMING said : Mr. Trotter had mentioned the Saunderson method of introducing a hydro-carbon into the arc. He happened to have made a great many experiments with that arc lamp, and the results were interesting. Saunderson took for the bottom carbon a hollow carbon that had an asbestos wick up it instead of the usual soft core, and at the bottom of the carbon there was a metal vessel in which he placed some paraffin, vaseline, or easily fusible hydrocarbon, which was conducted by the asbestos wick up the bottom carbon, and then introduced into the arc. He made a good many experiments on the effect of introducing such vapours into the arc. The experiments were made with a photometer of the Bunsen type, having a special disc adapted for such purposes, and the standard of light was a 5 c.p. incandescent lamp, which was carefully standardised before and after the experiments against a Vernon-Harcourt standard lamp. The arc lamp used was a hand-regulated arc lamp ; he found that was the best method, as his assistant, with his hand on the slow-motion screw, and his eye on the voltmeter, could do better than any automatic mechanism. The experiments consisted in measuring the photometric intensity in various directions, first for a pair of ordinary carbons and then for a pair of the same sized carbons, in the same arc, only the bottom carbon was cored and had the vaseline led up it from the metal vessel. The size of the carbons was in all cases 13mm., and the lower carbon was either a good cored 13mm. carbon, or else an improved tubular

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carbon supplied with paraffin oil. The results of these observations were then plotted down in the usual polar curve for the different angles. The red rays were excluded by a good ruby-red glass, tolerably monochromatic, and then also by a good signal green glass; and, taking the red rays first, it was found with the ordinary carbons they got the usual polar curve of certain dimensions, and on substituting for the bottom carbon the hollow Saunderson carbon with the paraffin in it; and drawing the same polar curve for the red rays, it lay outside the other altogether; there was not only more light in any direction but more light in all directions. A similar curve drawn for the green rays was found to lie outside the other, and the angle of greatest photometric intensity was somewhere about 30 or 40 degrees. Taking the intensity of the red ray for the ordinary carbon in the horizontal direction as unity, then the maximum red rays for the ordinary carbons in the direction of and 30deg. below the horizon was 3·44; the same rays in the improved carbon in the horizontal direction was 1·21, and in the direction of maximum intensity it was 4. The results were then converted into a figure, which Mr. Trotter said had no very definite meaning—the mean spherical candle-power; but the experiments showed that the mean spherical red light was improved 26 per cent., and the mean spherical green light was improved 24 or 25 per cent.; so that the introduction of this vapour into the arc had the effect of increasing that mean spherical candle-power in those ratios, and it was noticed that the introduction of this vapour into the arc greatly lengthened the arc. He found the arc about twice as long with the same voltage and currents when using the hollow carbons with oil, compared with its length with the ordinary carbons. Moreover, it was noticeable that there was certainly less cratering of the positive carbon when the prepared carbon was used. These results at the time were interesting, but he had not heard much since of this lamp in practice.

The table, given by Mr. Trotter, of light emitted per unit of surface from different sources was very interesting, showing the very wide range over which this luminous surface intensity extended for different sources of illumination. There was no mention in that table of a source of light which they might certainly have expected to find there, namely, an incandescent lamp. He could supply that figure which was missing. It came out very nearly identical with that of incandescent platinum. The surface intensity of illumination from melting platinum was given as 120 candles per square inch. The surface intensity of illumination of an incandescent carbon was about the same, viz., one-eighth of a candle per inch-mil. That was to say, if a unit of surface was taken whose length was an inch, whose shortest side was a thousandth of an inch, or a mil, and it was called an inch-mil, it was something at that rate. Mr. Trotter's figure in that table for an arc lamp, came out at 40 candles per inch mil. Therefore, comparing it with an incandescent lamp it was in the ratio of 40 to ⅛, or 320 to 1, a very striking difference indeed. One point of interest which ought to be decided—if it was possible to do so—by experiment was what ratio existed between those surface intensities and the true temperature of the surface; in other words, what function of the temperature of the surface was that surface intensity? It must be something like a cube or a fourth part. Dr. Fleming then described Rousseau's method of calculating mean spherical candle-power by rectangular co-ordinates.

Some time ago he commenced an investigation on a comparison between continuous and alternate-current arc lamps. He had an idea that there was an intrinsic inferiority in the alternate-current arc. He began by making a good arc lamp adapted for working either with an alternating current or with continuous currents, and determining the mean spherical candle-power of the arc taken from the polar curve, comparing that with the watts expended in the arc, and drawing a curve, or rather a series of curves, the horizontal distances being watts expended in the arc, and the vertical distances representing candle-power—that was done for different rays for the arc; for red rays and for a continuous current arc this watt candle-power curve was very nearly a straight line. He only stopped for want of better means of measuring the power taken up in an alternating arc.

Sir DAVID SALOMONS: Mr. Trotter started very early with these words: "A little consideration will show that the effect is precisely and identically the same as though the end of the positive carbon were flat." That was not strictly true. And afterwards he used all the arguments favourable to the surface of the carbon being cup-shaped, and therefore he arrived at the truth. If the positive carbon was flat the light issuing (omitting for a moment the refractive index) would gradually get less as the ray was more inclined, or less inclined, to this surface, so that if this carbon were really a flat surface it would be perfectly valueless for illuminating purposes, for the greatest quantity of light would be with the normal, and, therefore shielded by the negative carbon. But the fact of it being cup-shaped—they had a normal carbon, and therefore the light would be at a right angle from the source of light until they came to the line, when the carbon shielded it. If the carbon did burn flat, all the advantage got from the arc lamp would be gone, and it would be perfectly useless to attempt to use it until they made it burn cup-shaped.

Mr. R. W. WEEKES described a photometric apparatus, in which the light from an arc lamp in any direction was measured against the horizontal ray by means of mirrors.

*Mr. E. T. CARTER had been making some experiments since the Paper was read. According to the theory of heat they knew that the boiling point of a liquid depended upon the pressure which the liquid supported, and if the arc were placed in an atmosphere subjecting the vapour of the carbon to a higher pressure, the carbon would necessarily vapourise at a higher temperature. Consequently the surface of the carbon would be at a higher temperature, and there would be a higher efficiency, for the efficiency of any light source was a direct function of the temperature. He believed the temperature of the arc, as given by Sir William Siemens, was not 8,000° C., but 3,000° C. If it were assumed that the saturation curve of carbon vapour resembled somewhat the saturation curve of steam, then they could calculate approximately what the rise of temperature would be with a certain increase of pressure, and he had estimated if they subjected the arc to a pressure of eight atmospheres they would get a rise of temperature of the carbon of approximately 1,200 degrees; that was, more than the difference between the arc and glow lamp. The effect of this would be in accordance with the kinetic theory of heat. If the back E.M.F. was due to latent heat, as Dr. Thompson had clearly shown, a higher pressure would give a lower back E.M.F., and the minimum would be less than 39 volts. Mr. Carter then gave some calculations of the latent heat of carbon vapour.

*Prof. PERRY read a communication from Prof. SILVANUS P. THOMPSON, congratulating the author of the Paper upon the way in which he had straightened out the crooked problem of the distribution of light from the arc lamp. His intensely geometrical mode of viewing all matters had led him to discuss the arc lamp from a novel standpoint, and to give them the true solution of the problem. The starting point of Mr. Trotter's investigation was the recognition of the fact that the intrinsic brightness, per square millimetre, of the carbon surface of the crater was a fixed quantity. It also necessarily followed that the light emitted was always of precisely the same composition. He threw out the suggestion whether it was not worth while to reconsider the question of a standard of light, and adopt as a unit of light the light emitted by a square millimetre of crater. It was to be hoped that Mr. Trotter would be encouraged to complete his experiments on coloured shades, so as to give them a real daylight illumination. It was obvious that such shades could be used in conjunction with electric lamps, whether arc or incandescent, with far greater facility than with any flame lamps.

Mr. J. SHOOLBRED asked for the date of two communications published in *La Lumière Electrique*, one by M. Rousseau and the other by M. Palaz, containing some information with regard to polar curves. Some very interesting curves, the results of experiments carried out by MM. Sauttier-Lemonnier in Paris, were noticed; first, before the Society of Arts in 1878, and those and also some curves of alternate-current machines, taken from experiments carried out by M. Allard, of the French Lighthouse Department, afterwards appeared in a small publication in the year 1879.

*The PRESIDENT said that Mr. Mordey considered that he was justified in calling the light given off by a 10-ampere Brush lamp 2,000 and something candles, because the jury at the Crystal Palace in 1881 had reported that such was the efficiency of the Brush lamp. Mr. Mordey had coupled his name with that jury, and wished therefore to imply that the results were immaculate. However, he was not on that particular jury, and therefore was not responsible for the accuracy or inaccuracy of their results. Mr. Carter had assumed in his remarks that evening that the back E.M.F. in the arc was a perfectly definite and known number. He just wished to point out in passing that he was not aware of any tests whatever that had shown that there was a back E.M.F., still less that it had a value of 39 volts. Dr. Fleming's remarks with reference to the Saunderson lamp opened out a wide subject. The greater brightness probably was merely produced by greater length of the arc. The question of producing artificially, by means of arc or incandescent lamps, especially with arc lamps, lights of particular colours, was a subject which had interested him for some years past. On two occasions at the Royal Academy he had urged on Dr. Russell to bring the speaker's views before Sir Frederick Leighton, as to methods of arranging the pictures in the Royal Academy, and as to illuminating them with colour of a particular kind for a particular group of pictures. The question as to whether arc light was or was not blue with reference to white light was a subject which had been discussed backwards and forwards, and the advocates on each side considered that they were right. The explanation of that was that both were right. All depended upon what they meant by white light. They could easily prove that the arc was red compared with the sun by using what Mr. Trotter rather despised, red and green glasses. It was perfectly true, as he said, that they could not combine the results obtained with red and green glasses; they could not use the arithmetic mean, or the geometric mean, or the square root of the mean square; but he did not think that was any objection to making experiments with red and green glasses. In the same way they might speak about the experience of a person and the ability of a person, but they could not take the arithmetic mean, or the geometric mean, or the square root of the mean square of these two qualities; yet when judging of the value of a person they thought of his experience as compared with his ability. Arc lights were as a rule used not in the daytime but at night, and during the night white light was not sunlight. That brought them to the consideration of what was the definition of white light. He believed the proper definition was what they saw most of. Simply that. Up to the present time they had not seen most of arc lights during the evening, and so the standard of white light at night was gas light, and compared with that the arc was certainly blue.

*Mr. A. P. TROTTER apologised to the meeting for not being able to show the experiments which had been a second time promised. The terminals from the supply company had been there for ten days, but the insurance inspector had not been there. He had hoped to have shown one or two additional experiments with reference to what Mr. Swinburne said, and what Prof. Silvanus Thompson had also suggested, about using a portion of the crater as the unit of candle-power. Mr. Higgins had drawn his attention to the fact that the core of a cored carbon was distinctly less bright than the rest of the carbon—it was not such a good carbon for ordinary purposes, but had a valuable function in centring the arc. He suggested to Mr. Higgins to take a double carbon, one half as good as could be got, and the other a piece of battery carbon, and tie them together side by side, to see if one half of the crater was worse than the other. He had tried the experiment, but found that the soft carbon flared and flamed so much that it was difficult to make a test. This suggested that not only the emissivity but also the volatility of the carbon must be considered. The temperature must go down if the carbon was more volatile, and therefore he thought it could hardly be depended upon for a unit of light. The question had been raised about alternate-current arcs. He had had very

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little experience indeed with alternate-current arcs, but was glad to hear Mr. Mordey had a high opinion of them, for that must mean that there was a great deal in them. The crater had been described as being a horizontal disc where it was really concave, and Sir David Salomons had given his views on the subject. He ventured to disagree altogether with them, but would not dwell upon the reasons. He could only repeat that no tilting of a luminous surface could make it brighter or less bright. Mr. Mordey had said that the alternating arc had time to get cool, and suggested that there was, as it were, a thermal fly-wheel, owing to the mass of carbon behind the crater, which would have enough heat to keep the arc going. If the crater were well focussed on a screen, and the current was reduced a little, the crater would suddenly curdle all over in a sort of flocks, and an instant afterwards the crater would diminish in size. He thought that as vapourising of the carbon took place at the surface and at the surface only, that the light also was given out by the surface alone where the truly white-heat carbon was really volatilised. An incandescent lamp carbon was different, the heat was all the way through the filament, and was in fact, greater in the interior.

Mr. Swinburne had pointed out a curious discrepancy between the light given by the sun per square inch and that given by carbon. A piece of the sun cut out and allowed to cool, ought to be 10 or 20 times blacker than carbon. But the pressure on the sun might be some tons per sq. in., and it was very possible that that might so raise the temperature, and thus account for it. He fully expected to have heard some remarks on some experiments made at the Standardising Institution with coloured shades. He understood that some experiments were made there with a screen, not blue, but grey, and with the Sun lamp, which was the Lampe Soleil resuscitated, and that some very good results had been obtained. Ayrton had given a very good reason for showing why they might use red and green glasses, and his analogue of ability and experience was most excellent. He said white light was what they got most of, but that was unfortunately not the case with ability and experience.

Dr. J. H. GLADSTONE then commenced the reading of a Paper by Mr. W. Hibbert and himself on "The Causes of the Changes of Electromotive Force in Secondary Batteries," but had not concluded when the time for adjournment arrived.

ON THE CAUSE OF THE CHANGES OF ELECTROMOTIVE FORCE IN SECONDARY BATTERIES.*

BY J. H. GLADSTONE, F.R.S., AND WALTER HIBBERT.

In 1882, Dr. Gladstone and the late Mr. Tribe sent to *Nature* four letters on the "Chemistry of Secondary Batteries." The main point established in these Papers was the all-important functions of sulphate of lead. They showed, in fact, that when a lead lead-peroxide cell is discharged, "sulphate of lead is the ultimate product on both plates;" and when it is charged again, "this lead sulphate is oxidated on the one plate, and reduced on the other."

In 1883, another letter appeared, in which, among other things, the effect of different strengths of acid when the cell is being charged was investigated, and the existence of occluded hydrogen, ozone, and hydrogen dioxide was considered.

These letters were subsequently published in book form.† In a Paper of the same authors in the *Journal* of the Chemical Society for 1883, p. 345, reference was made to the production of persulphuric acid in the electrolysis of oil of vitriol.

In 1883, Prof. Frankland‡ obtained substantially the same results, and proposed to ascertain the state of a cell during charge or discharge by observing the density of the acid.

In 1889, Messrs. Duncan and Wiegand§ investigated the rate of diffusion of the acid out of the pores of the spongy masses in the plates of a secondary battery.

In 1889, Heim‖ investigated the change in capacity of secondary batteries when used with different strengths of acid, and gave the E.M.F.'s observed when the strength varied from 10 to 35 per cent. H_2SO_4.

In 1890, we published experiments¶ which led us to regard the "abnormal initial E.M.F. of a secondary battery as due to inequality of acid strength, and its gradual disappearance as due to equalisation of strength produced by diffusion."

Shortly after this, an elaborate and valuable series of observations on accumulators was published by Messrs. Ayrton, Lamb, Smith, and Woods,** who have given curves showing the changes in potential difference under many conditions of working. They allude to our suggestion, and conclude on various grounds that it is insufficient to explain some of the phenomena.

In the discussion which followed this Paper, Mr. Hibbert urged that curves given by the authors afforded confirmation of our hypothesis.

Subsequently, two Papers were sent to the Royal Society by Mr. G. H. Robertson and Professor Armstrong,* of which only the abstracts have been printed. From these, as well as from a lecture by Mr. Robertson at the Society of Arts,† we gather that they attribute much to the formation of persulphuric acid and hydrogen dioxide.

We have lately been making additional experiments on the matter, which have led us to the conclusion that *variations in the strength of the sulphuric acid are the main cause of the variations in E.M.F.*

We propose to consider—

1st. What variations of strength of acid actually occur during charge, repose, and discharge.

2nd. Experimental determination of the change of E.M.F. produced by changing the strength of acid.

3rd. How far this is capable of explaining all that is known about the changes of E.M.F.

4th. Confirmations, experimental and theoretical.

5th. Other suggested causes.

PART I.—*What Variations of Strength of Acid actually occur during Charge, Repose, and Discharge.*

(*a*) *Changes during Charge.*—If we start with a properly formed cell which has been discharged, we have to deal with two leaden supports, on one of which there is a mixture of lead sulphate, $PbSO_4$, with more or less lead peroxide, PbO_2, and on the other a mixture of lead sulphate, $PbSO_4$, with more or less spongy metallic lead. Each of these mixtures is a porous layer the interstices of which may penetrate to the leaden support.

To avoid confusion, we propose describing the one as the PbO plate, and the other as the Pb plate.

If these be charged, the chemical action consists of the conversion of the lead sulphate on the one plate into PbO_2, and on the other into spongy lead, and the electrolytic change may be expressed thus:

$$PbSO_4 + H_2O \ldots . H_2O + PbSO_4 = PbO_2 + H_2SO_4 \ldots . H_2SO_4 + Pb.$$

It is evident that during this process sulphuric acid is formed in the pores of both plates, whilst at the same time an equivalent amount of water disappears.

Apart from this electro-chemical result which is equal on both sides, it is well known that during an electrolytic decomposition there is a gradual heaping up of the acid at what is now called the positive electrode, and a drawing of it away from the other. This increase of strength of acid at the peroxide plate may be seen by the descent of a denser layer of acid through the clear space under the plate. Indeed, it is well known that there is a circulation in the cell, the acid becoming stronger at the bottom and weaker at the top.

But to remove any doubt as to the strength of acid in the pores of the peroxide being greater than in those of the other plate, we made a direct experiment.

A cell was made of two small fully formed plates, each in a porous pot containing about 30 cubic centimetres of acid. These porous pots were placed in a large dish of the same acid and a current of 0·2 ampere sent through for two hours. After that time, the acid in the pot containing the PbO_2 plate had increased three per cent., whilst that round the Pb plate had diminished one per cent.

Of course, during the whole process of charging, diffusion is tending to equalise the strength of the acid, but it is much impeded by the capillary nature of the passages through which it must take place. It is quite conceivable that towards the end of charging, a film of the strongest acid—that is, H_2SO_4 itself—covers the working surface of the PbO_2 plate.

All these actions account for the well-known fact that during the charge the whole body of the liquid in a working cell rises in density by somewhere about 0·04.

(*b*.) *Changes on Repose.*—At the end of charging, the PbO_2 plate consists of porous peroxide attached to the lead support, surrounded by strong sulphuric acid. This sulphuric acid will diffuse out into the intermediate liquid at a rate which Messrs. Duncan and Wiegand's results show to be rapid at first. Complete equalisation is, however, a very slow process, to be reckoned by hours rather than by minutes.

But there are other actions reducing the sulphuric acid in the pores at the same time. The PbO_2 and its supporting lead are in a condition to set up energetic local action with the formation of sulphate of lead, and consequent absorption of sulphuric acid from the liquid. The chemical change is as follows:—

$$PbO_2 + H_2SO_4 \ldots\ldots H_2SO_4 + Pb = PbSO_4 + H_2O \ldots\ldots H_2O + PbSO_4.$$

(It must be remembered that the Pb in this equation is the lead support for the peroxide. Common experience shows that it is corroded during use.)

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* A Paper read on Thursday, May 12, 1892, before the Institution of Electrical Engineers.

† "The Chemistry of Secondary Batteries," Macmillan, 1883.

‡ *Proc.* Roy. Soc., Vol. XXXV., p. 67.

§ *Electrical World*, June 15, 1889.

‖ *El. Zeit.*, 1889, p. 88.

¶ "Notes on Secondary Batteries," *Phil. Mag.*, 1890, p. 169.

** *Jour.* Inst. Elec. Engineers, 1890, pp. 539 and 660.

* *Proc.* Roy. Soc., 1891, pp. 105 and 108.

† *Soc. Arts Journal*, Dec. 4, 1891.

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This action clearly will absorb sulphuric acid from the liquid in the pores and replace it by water.

In a well-charged plate, there is always at first an evolution of a little oxygen gas, which has been attributed* to the reaction of hydrogen dioxide on peroxide of lead.

$$PbO_2 + H_2O_2 = PbO + H_2O + O_2.$$

If this be the case, the oxide of lead (PbO) formed must also abstract its equivalent of sulphuric acid from the liquid.

Of the three causes of weakening—diffusion, local action, and reduction by H_2O_2—the first goes on till the acid in the pores is brought down to the same strength as that in the intermediate liquid. But the local action may still continue for many days and will tend to keep the acid in the pores a little weaker than that in the external liquid, notwithstanding the return diffusion of acid towards the plate.

Turning now to the Pb plate in repose, we find none of the above actions taking place, except the slow equalisation of strength produced by diffusion.

But there is an action peculiar to this plate—that is, a direct slow chemical action of the sulphuric acid on the lead, producing lead sulphate and hydrogen gas.† The equation is—

$$Pb + H_2SO_4 = PbSO_4 + H_2.$$

This must gradually produce a weakening of the acid in the pores, and it is important to notice that diffusion, which is always slow, will be almost entirely prevented by the choking up of the capillary passages by the gas evolved.

We have indicated the probability that towards the end of a charge there is a film of the strongest acid against the working surface of the PbO_2 plate. If this be true, it is evident that as soon as repose begins, such a film will almost immediately disappear, owing to diffusion into adjacent liquid, whether in the pores or out of them.

(*c.*) *Changes during Discharge.*—As soon as the discharge begins, a still more rapid reduction of the strength of acid may be expected. Diffusion, local action, and reduction by H_2O_2 will still take place on the PbO_2 plate, and the direct chemical action on the Pb plate, but on each plate there is superadded the ordinary discharge reaction of the cell. The form of the equation for discharge is the same as that already given for local action, namely—

$$PbO_2 + H_2SO_4 \ldots . H_2SO_4 + Pb = PbSO_4 + H_2O \ldots . H_2O + PbSO_4$$

(In this case the Pb represents spongy lead on the Pb plate.)

But while the absorption of sulphuric acid and production of water thus goes on in both plates, electrical transference of the H_2SO_4 now takes place from the PbO_2 to the Pb plate, causing an additional weakening of the acid in the pores of the first.

If discharge has commenced immediately upon the cessation of charging, these different causes will combine to produce a very rapid decrease in the strength of the acid at the PbO_2 plate.

In any case, a period must soon arise in which the great excess of sulphuric acid originally about the PbO_2 plate has disappeared through these various agencies, and the acid on both plates will be reduced to pretty nearly the same strength as that of the intermediate liquid. After this, there will be a gradual withdrawal of acid from the liquid in the pores, more or less compensated by diffusion inwards from the intermediate liquid. This, of course, brings about the reduction in the strength of the whole acid, which is well known to take place during discharge.

The strength of the acid in the pores will be determined by the relative values of the rate of withdrawal and the rate of diffusion. But while the rate of withdrawal continues constant for a given discharge current, the rate of diffusion rapidly diminishes.‡ The rate of weakening of the acid is, therefore, a constantly increasing one, and may finally become so rapid that the acid strength of the liquid against the working surfaces of the plates is very low or almost *nil*.

In such a case we may expect the formation of the white compound described by Gladstone and Tribe,§ which, when analysed, seemed to be a basic compound of the composition $2PbSO_4 . PbO$.

(*d.*) *Changes on Repose after Prolonged Discharge.*—If through prolonged discharge the acid against the working surfaces has become very weak, and the discharge is then stopped, it is evident that the acid in the pores will quickly increase in density, and uniformity of strength in and outside the pores will be restored after a while; but the general strength will always be lower than the original value. A renewal of the discharge will, however, soon lead to exhaustion of the acid against the working surfaces.

* "Chemistry of Secondary Batteries," p. 51.

† Gladstone and Hibbert, *Phil. Mag.*, 1890, p. 164; Ayrton and others, *Jour.* Inst. Elec. Engineers, 1890, p. 680.

‡ This might be expected from the partial clogging of the pores by the $PbSO_4$ formed on both plates, and it has been experimentally shown to be the case by Messrs. Duncan and Wiegand.

§ "Chem. of Sec. Batts.," p. 46.

PART II.—*Experimental Determination of the Change of Electromotive Force produced by Changing the Strength of Acid.*

It is a matter of general knowledge that the E.M.F. of an accumulator rises slightly when the strength of the acid is increased. Incidental determinations of the rise occur in several Papers, of which we may mention one by Preece* and another by Heim.†

In 1890, thinking it probable that the chief cause of the high E.M.F. was "the great inequality in strength of acid produced by the charging current," we made some experiments which were described, with tabulated results, before the Physical Society.§ Instead of repeating these, we now throw the results into a diagram of curves (Fig. 1).

For each case, the ordinates represent E.M.F. of the cell in volts, the abscissæ represent time in minutes. The figures attached to the curves show the percentage strength of the acid round the PbO_2 plate. The Pb plate was always in 18·5 per cent. acid.

The curves show—first, that in each experiment the E.M.F. at the commencement of discharge is about the same value, 2·58 or 2·6.

Secondly, that the fall after stopping the charging current was initially more rapid in the case of the weaker acid. The subsequent and more permanent E.M.F. also depends on the strength of the acid, the value for 58 per cent. acid being 2·27 volts; for 34 per cent. acid, about 2·15 volts; for 18·5 per cent. acid, about 2·01 volts. When the cell has been in repose 15 minutes, the weakest acid gave 0·26 volt less than the strongest, and 0·14 volt less than the 34 per cent. acid.

Thirdly, that if, when the E.M.F. has fallen, the strength of the acid be increased, the E.M.F. quickly rises, and, as the acid soaks into the pores, eventually attains about the same value as if that particular strength of acid had been maintained throughout.

This seemed to justify our conclusion, but we were desirous of obtaining more direct evidence of the effect of varying strength of acid. In our old experiments we measured E.M.F. by the condenser method, and have again found it useful in many experiments. But we have now made more accurate determinations by the potentiometer, and in one series of experiments by observing the current obtained through a high resistance.

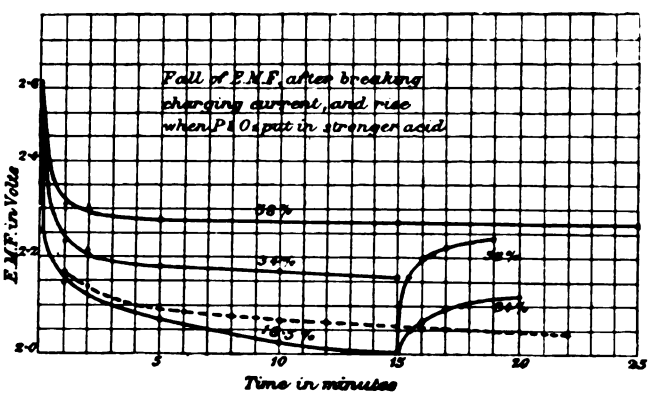

FIG. 1.

Throughout the new experiments we have employed the same two plates. The supports consisted of thick lead wire doubled on itself. These were pasted with red lead and then "formed" in the usual way, until the paste on one was pure lead, and on the other pure peroxide of lead. The active part of each was about 3in. long and half an inch diameter. The containing vessel and acid varied according to requirement, as described below for the particular experiments.

We found that on transferring the plates from a weaker to a stronger acid the E.M.F. begins to go up, at first rapidly, afterwards more and more slowly. But the final value is not reached for some hours. It was impossible to allow so much time for each observation, and in our earlier experiments we made our determination of E.M.F. at the end of twenty minutes or so. Consequently in these our figures do not represent the ultimate value of the E.M.F. for that strength of acid, but they do not fall much short of it.

In all experiments the plates were fully charged, and before being used were washed free from the liquid products of electrolysis.

First Series.

In the first series both plates were immersed in acids of the same strength. When one observation had been made, the plates were quickly transferred to another cell containing stronger acid, and the E.M.F. occasionally tested for fifteen minutes, when it was

* *Proc.* Roy. Soc., 1883, p. 460. § *El. Zeit.*, 1889, p. 88.

† *Phil. Mag.*, 1890, p. 168.

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finally observed, and the plates again removed into a cell containing still stronger acid, and so on. The following table gives the results :—

Table I.

Acid in cell round both plates.		E.M.F. of cell in volts.
Density.	Percentage strength.	
1·045	6·5	1·887
1·065	9·5	1·898
1·080	11·5	1·915
1·115	16·2	1·943
1·157	21·7	1·978
1·217	29·2	2·048
1·254	33·7	2·088
1·335	43·0	2·170

The last acid was found to act vigorously on the spongy lead, so that this series was discontinued.

Second Series.

The same procedure was followed, with the exception that the Pb plate was kept throughout in acid of density 1·098 = 14 per cent. The peroxide was transferred from one to another of a series of porous pots filled with acids of the strength given below :—

Table II.

Acid round PbO_2 Plate.		E.M.F. in volts.
Density.	Percentage strength.	
1·045	6·5	1·926
1·065	9·5	1·932
1·080	11·5	1·939
1·115	16·2	1·949
1·157	21·7	1·963
1·217	29·2	1·986
1·254	33·7	2·013
1·335	43·0	2·061
1·53*	63·0	2·22
1·75*	81·0	2·33

The results of the two series are plotted in the following diagram (Fig. 2) :—

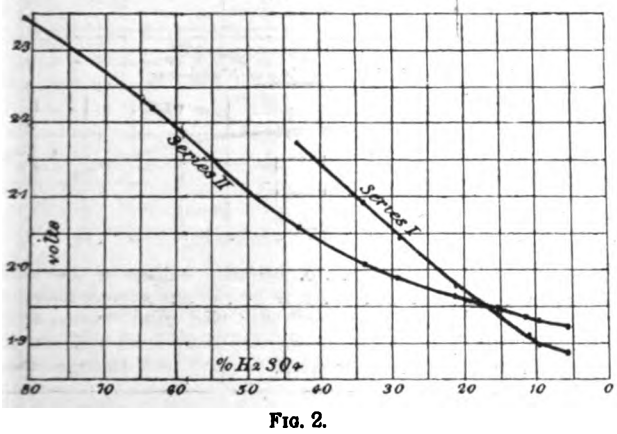

FIG. 2.

It will be seen—first, that in both cases the E.M.F. increases with the strength of the acid, although in Curve II. there is no change in the acid at the Pb plate ; secondly, there is no coincidence of the curves except where the conditions of the experiments are practically identical ; thirdly, that for any given abscissa the E.M.F. in Curve I. is smaller than that in Curve II. when the acid about the Pb plate is less than 14 per cent., and greater when it is more. Hence it follows that the E.M.F. depends on the strength of the acid at both electrodes.

Third Series.

Not being satisfied with the range or the accuracy of the preceding series, we endeavoured to obtain a curve representing the relation between E.M.F. and strength of acid within the widest limits.

After preliminary trials and considerations, we adopted the following plan. The experiments were divided into two parts, in consequence of the action of strong acid on spongy lead.

* The two last observations really belong to another set of experiments, where the acid round the lead = 23 per cent.

In the first part, we commenced with an acid of 5·6 per cent., and worked upwards to 49 per cent., allowing the plates to stand half an hour in each acid before final observation of E.M.F. The process was then reversed, working downwards through the same acids to 5·6 per cent. again, and then continued through weaker acids to a mere trace—less than 0·05 per cent.—and the cycle finished by returning once more to 5·6 per cent. As even half an hour or an hour is scarcely sufficient for equalisation of the strength of the acid within and without the pores of the plates, it may be expected that the ascending series would scarcely represent the full effect of the rise, whilst the descending series would scarcely represent the full effect of the fall. We therefore give in Table III., not only the numbers actually obtained, but also the means of the ascending and descending series, which cannot be far from the true values. We have proof of this in the case of the 5·6 per cent. acid, where the mean is 1·89 volts, while the true E.M.F., as very carefully determined previously for the same strength, was 1·88 volts. This agreement also proves that no appreciable change had come over the plates during the operations.

Table III.

Time of soaking.	Density of acid.	Per cent. H_2SO_4.	E.M.F. in volts.		
			Ascending.	Descending	Mean.
1 hour	...	Trace	...	1·507	1·507
,,	1·008	1·2	1·747	1·777	1·762
,,	1·013	2·0	1·792	1·825	1·808
,,	1·020	3·1	1·835	1·867	1·851
,,	1·037	5·6	1·875	1·908	1·891
30 minutes	1·071	10·4	1·922	1·953	1·937
,,	1·154	21·3	1·993	2·016	2·004
,,	1·233	31·2	2·055	2·066	2·060
15 ,,	1·388	49·0	2·149	...	2·149

In the second part of the experiments of this series the Pb plate stood throughout in 27 per cent. acid. We commenced with the PbO_2 plate in 43·5 per cent. acid, ascended to 88·5 per cent., and then returned to 43·5 again. A longer time was here allowed for diffusion, as the strong acid is very viscid. Notwithstanding this longer soaking, the differences between the ascending and descending series are greater than before. The results are given in the following table :—

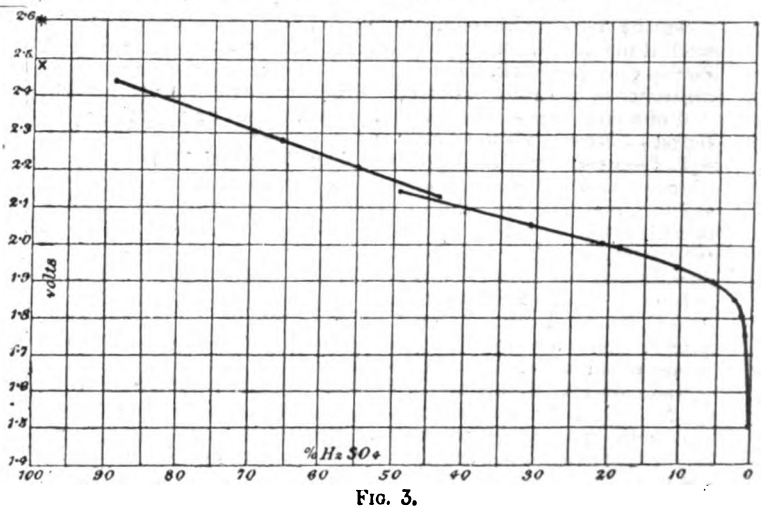

FIG. 3.

Table IV.

Time of soaking peroxide plate.	Acid round peroxide.		E.M.F.		
	Density.	% H_2SO_4.	Ascending.	Descending	Mean.
50 minutes	1·338	43·5	2·106	2·163	2·135
50 ,,	1·446	54·8	2·179	2·233	2·206
50 ,,	1·569	66·0	2·259	2·298	2·277
60 ,,	1·605	69·0	2·279	2·342	2·310
60 ,,	1·723	79·0	2·354	2·398	2·376
60 ,,	1·814	88·5	2·442	...	2·442

The mean results of Tables III. and IV. are given in the above diagram (Fig. 3) :—

The two curves very nearly join, and when it is considered that the highest E.M.F. of the lower curve is almost certainly too low,

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and the lowest E.M.F. of the upper curve too high, the coincidence it striking.

An attempt was made to get an observation in very strong acid. The fully charged PbO_2 plate was washed in water, and dried at 100° C. It was then soaked in 95 per cent. acid. After 34 minutes' soaking the E.M.F. was observed, and the plate then placed in weaker acid. In consequence of absorption of water from the adjacent liquid of the cell, as well as from the atmosphere, the acid round the PbO_2 plate fell from 91·5 per cent., the Pb plate standing all through in 27·5 per cent. acid. Results are given below, and are fairly confirmatory of the previous figures :—

Table V.

Time of soaking.	Acid round PbO_2 plate.	E.M.F.
34 minutes	91·5 %	2·44
53 "	77·5 %	2·37
67 "	65·5 %	2·28
97 "	53·0 %	2·16

The highest E.M.F. here obtained (2·44) is very nearly the same as that given in Table IV. for 88 per cent. acid.

A still further effort was made to get an observation in the strongest acid. A PbO_2 plate was soaked all night in 80 per cent. acid, and in the morning transferred to a jar containing 99 per cent. H_2SO_4. This was kept under a closed bell jar for four hours, after which the E.M.F. between the PbO_2 in this strong acid and a Pb plate in 25 per cent. acid was measured by potentiometer. The value was 2·47 volts, which, after 30 minutes' further standing, rose to 2·48 volts nearly. This is represented in Fig. 3 by the small cross ×.

It was expected that a still higher voltage could be obtained if both plates were immersed in the strongest acid, undiluted H_2SO_4. The difficulty was that this acid acts pretty readily on the spongy coating of the ordinary Pb plate, so we made an experiment with a strip of ordinary clean sheet lead. Placing this in the same H_2SO_4 in which the PbO_2 plate had been standing for some hours, the E.M.F. was found to be as high as 2,607 * volts. This is indicated in Fig. 3 by an asterisk (*).

PART III.—*How far are these Results capable of explaining all that is known about Changes of E.M.F.*

At the very beginning, it is evident that the experiments described in Part II. more than cover the range of variation in E.M.F. during ordinary work. For these limits are : a maximum potential difference of 2·5 volts at the end of a charge, and 1·8 volts at the end of a discharge—figures which come within the variations produced by strong and weak acid.

But our results go much farther than this ; and for the purpose of detailed consideration we shall compare them (as shown in Parts I. and II.) with the valuable observations of Prof. Ayrton and his collaborateurs. Their Papers in the *Journal* of the Institute† contain the most elaborate and trustworthy account of working variations of potential difference which has yet been published.

In order to make the comparison more evident to the reader, we give the two time curves (Figs. 4 and 5) of E.M.F. in charge and discharge. They are deduced from the curves of potential difference values given by Prof. Ayrton and others in the figures opposite p. 661, by making allowance for the resistance as exhibited on pp. 590 and 592. We indicate for certain marked points in the curves the percentage strength of the acid in the general body of the cell as deduced from the specific gravities given on pp. 672 and 673.

As far as charging is concerned, we have already shown that sulphuric acid must be continuously formed by the decomposition of the sulphate on each plate, and that the acid must become more and more concentrated, especially against the PbO_2 plate. If our views be correct, this must give rise to an immediate rapid increase of E.M.F. ; but as the action proceeds, the tendency of the heavy acid to sink towards the bottom of the vessel, or to diffuse into the weaker intermediate acid, will become greater, and a point will be reached when the production of sulphuric acid against the plate will be nearly counterbalanced by its dispersal. The E.M.F. will still rise slowly, because the intermediate acid is gradually increasing in strength.

This evidently is the tale that is told by Fig. 4. Beginning with an external acid of 24·6 per cent. and a corresponding E.M.F. of about 2·03 volts, there is a rapid rise—so rapid, indeed, that by the end of half an hour the E.M.F. has become 2·1 (which is about equal to what would be given by a 40 per cent. acid at each plate—*see* Fig. 3), whilst the intermediate acid has not risen, but is only 24·5 per cent. The increase of E.M.F. due to increase of strength of acid against the plates then becomes very slow ; but after about nine hours it is found to have risen to what we may look upon as 45 per cent. or more against the PbO_2 plate, while the intermediate acid in the cell has risen to 27 per cent. It subsequently rises against the working surfaces of the plates to 55, and eventually to at least 66 per cent., or probably much more, though the strength is little increased in the body of the cell.

When discharge commences we have shown that there must be a very rapid weakening of the acid from diffusion and formation of lead sulphate till the losses are fully counterbalanced from the intermediate acid. There will then be no material reduction till the intermediate acid is considerably reduced or prevented diffusing freely into the pores of the plates. This is the explanation of Fig. 5. We see the rapid fall of E.M.F., the bulk of which takes place in the first few minutes (*see* Ayrton and others, pp. 545 and 546, and our experiments, Fig. 1). After about half an hour the E.M.F. is reduced to about 2·03 volts, indicating about 25 per cent. H_2SO_4 against the plates, while the intermediate acid is 27·8 per cent. This state of things lasts for some hours, but the absorption of the free acid that is in the pores of the plates gradually reduces the strength there below that of the intermediate liquid, so that after eight hours the internal acid is about 22 per cent., while the external strength has sunk only to about 26 per cent. The acid against the plates then declines more rapidly, so that in four hours more the E.M.F. is equal to that which would be given by 7 per cent. at each plate, while the intermediate acid has scarcely sunk below 25 per cent.

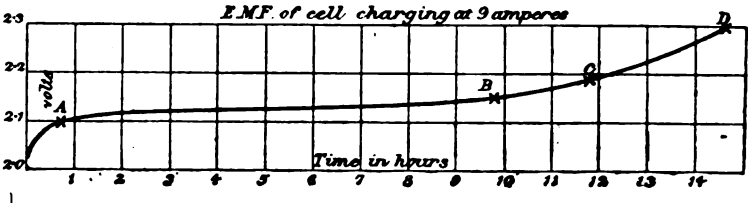

FIG. 4.

Acid in General Body of Cell during Charge.

At point.	Density given.	% H_2SO_4.
A	1·178	24·5
B	1·198	27·0
C	1·201	27·4
D	1·206	28·0

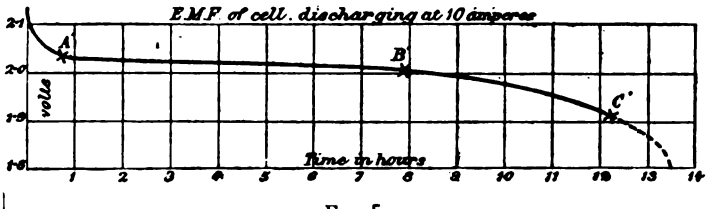

FIG. 5.

Acid in General Body of Cell during Discharge.

At point.	Density given.	% H_2SO_4.
A'	1·205	27·8
B'	1·189	25·9
C'	1·180	24·8

We have already mentioned in Section I. that when the acid is very weak the compound $2PbSO_4.PbO$ may begin to form. Should this be the case, the acid absorbed per ampere-hour would be less than before by about one-third. This is about what was found by Dr. Frankland, and described by him in the discussion on the Paper by Prof. Ayrton and his colleagues (*Jour.* Inst., XIX., 698). Dr. Frankland shows that in some prolonged discharges there was some such reduction of the absorbed acid, and that the diminished rate of absorption began when the voltage fell below 1·8—a figure indicative, on our hypothesis, of a weak acid in the pores of the plates.

We have also shown that if through prolonged discharge the acid in the pores has become very weak, a stoppage of the discharge ought soon to bring up the acid towards what it is outside. The E.M.F. ought therefore quickly to increase to the normal, or nearly so. This rise after rest was observed in very early days, and has been frequently discussed, as, for example, by Messrs. Gladstone and Tribe ("Chem. Secondary Batts.," p. 28), and by Prof. Ayrton and other.

* The same E.M.F. was obtained whether the lead was cleaned by scraping with a knife, or by washing with acetic acid.

† *Loc. cit.*, pp. 661, 545.

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We have already seen that if a charged cell be allowed to rest without discharge, the acid in the interstices of the Pb plate is slowly weakened by its action on the lead with the evolution of hydrogen gas. The gas will tend to clog the interstices and impede the stronger acid outside from diffusing inwards.* The lower strength of internal acid will produce a lower E.M.F. than would be obtained if the internal acid were of the same strength as the external. In other words, a discharge after long repose ought to commence with a somewhat low E.M.F. But one effect of discharging will be to remove the impediment to free diffusion produced by the enclosed gas, and thus tend to increase the strength of the internal acid, with a consequent small rise in E.M.F. as the discharge goes on.

Now Prof. Ayrton and his colleagues obtained these very results in two instances. The curves representing one of these we have reproduced (Fig. 6) from their Paper, with two previous normal curves, *a* and *b*, for comparison.

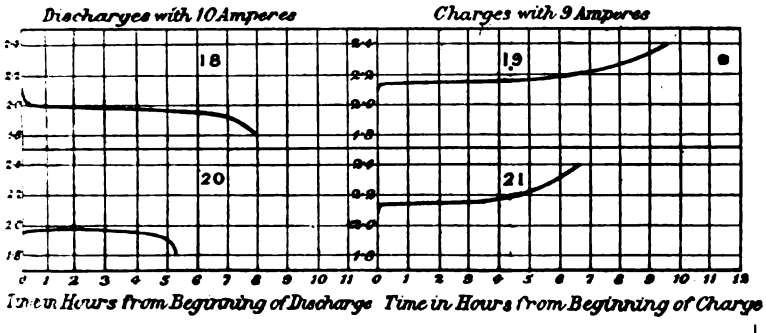


FIG. 6.

In both the instances not only had the potential difference sunk below the normal during repose, but it never quite recovered its normal value, while the fall towards the end of the action took place in about two-thirds of the normal time. On subsequent charging, the process of decomposing the $PbSO_4$ lasted for only two-thirds of the usual time. All this points to an early clogging of the pores, and a consequent diminution of the total chemical action.

In this way we explain what the discoverers of the effect regard as a difficulty. The real problem that had to be solved was not, why did the potential difference go up during discharge? but, why had it gone down during the many days' repose?

(To be continued.)

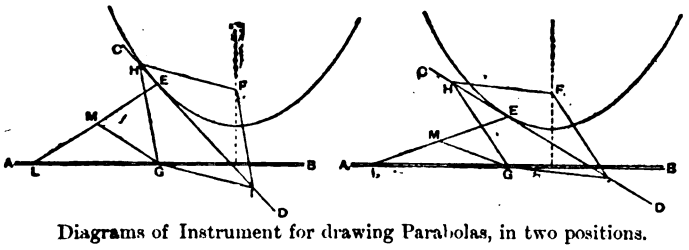
PHYSICAL SOCIETY.

At the ordinary meeting of this Society on the 13th inst., Dr. E. Atkinson, Treasurer, in the chair,

Mr. R. INWARDS read a Paper on

"An Instrument for Drawing Parabolas."

It was designed for drawing curves of short focus such as are required for reflectors and for diagrams of the paths of projectiles, &c. Its construction is based on the fundamental property that every point on the curve is equidistant from the focus and directrix. In the diagram below, A B is a slot representing the directrix, and



Diagrams of Instrument for drawing Parabolas, in two positions.

F G H I a rhombus jointed at the corners and pivoted at F, whilst C D represents a bar capable of sliding through guides at H and I. A rod L E is coupled to G by a bar G M, such that the lengths L M, M E, and M G are equal. As L and G slide along A B the point E describes a parabola whose latus rectum depends on the distance of F from A B. In the instrument, F is carried by a slotted arm, so that its position is adjustable. G E is always perpendicular to A B and equal to E F.

* There may also be a slow formation of lead sulphate on either plate, due to the local action described further on.

Prof. BOYS inquired whether the instrument could be modified to draw any conic section by arranging that the ratio of E F to E G, instead of being unity, might be greater or less than unity.

Prof. PERRY said an instrument for drawing curves represented by the equation $y = x^n$ was greatly needed for engineering work.

Mr. F. H. NALDER exhibited and described

"Some Electrical Instruments."

The first shown was a ballistic galvanometer with one pair of coils, the distinguishing features of which were accessibility, small damping, great sensitiveness, and the arrangement of the control. The control is effected by a "tail magnet," carried on a horizontal tube supported by a pillar outside the case, as suggested by Prof. R. M. Walmsley. A small magnet on the cover serves for zero adjustment. The suspended system consists of four bell magnets, two being in the middle of the coil and one at top and bottom respectively arranged so as to be astatic. The sensitiveness of the instrument shown was such that $\frac{1}{4}$ of a microcoulomb gave 300 divisions (fortieths of an inch) when the periodic time was 10 seconds and scale distance about 3ft. Resistance of galvanometer about 10,000 ohms. To bring the needle to rest quickly, a damping coil mounted on an adjustable stand and a special reversing key with resistances in its base, are provided. The key has successive contacts arranged so that when pressed lightly only a weak current passes round the damping coil, whilst when pressed further a much stronger current passes. The strong currents are used to check the large elongations, and the weak ones for finally bringing to zero. A lamp-stand, with semi-transparent scale arranged for use with a glow-lamp, was next shown. Instead of reading by the image of the filament, as is ordinarily done, the lantern is arranged to give a bright disc of light with a black line across the middle.

Mr. BLAKESLEY asked if the galvanometer was astatic. For damping non-astatic ones he had found it useful to wind several turns of wire round the bobbin, and put them in series with a few thermo-electric junctions warmed by the hand and a key.

In reply, Mr. NALDER said the galvanometer was astatic, but the damping coil could be placed so as to act on one pair of magnets more than on the other.

A Paper on

"A Portable Instrument for Measuring Magnetic Fields, with some Observations on the Strength of the Stray Fields of Dynamos,"

by Mr. E. EDGAR and Mr. H. STANSFIELD, was then read. The instrument was described as an inversion of a d'Arsonval galvanometer, for the torque necessary to maintain a suspended coil conveying a constant current parallel to the field gives a measure of the strength of the field. The constant current is furnished by a Hellensen's dry cell, which the authors found remarkably constant. The instrument consists of a coil of about 50 ohms wound on mica and suspended by two German silver strips within a tube. A pointer is fixed to the mica, and a divided head, to which the outer end of one strip is attached, serves to measure the torsion. Within the head chamber is a commutator, which automatically reverses the current in the coil when the head is turned in opposite directions from zero. Two readings may thus be taken to eliminate gravity errors due to want of perfect balance in the coil. Means are provided for adjusting and measuring the tension of the suspensions.

The authors have tested the fields of dynamos at the Crystal Palace Exhibition and elsewhere, and the results obtained are given in the Paper. It is noted that the stray fields of multipolar machines fall off much more rapidly than those of two-pole dynamos as the distances are increased, and that near edges and corners of the magnets the fields are much stronger than near flat surfaces. The disturbing effect of armature reactions on the strength of the stray fields were measured, and shapes of the fields observed in some cases. Experiments on magnetised watches are described in the Paper.

Mr. WHIPPLE said the Kew Committee were to some extent responsible for the experiments described, for it was on their account that the investigations were commenced. In connection with the rating of so-called non-magnetic watches, it was necessary to know what strength of fields they were likely to be subjected to. The instrument devised for making the tests was a very interesting one, and the results obtained by it of great value.

Mr. A. P. TROTTER hoped the authors would supplement their work by tracing out the directions of the stray fields of dynamos, and he described a simple method of doing this by a test needle used as an india-rubber stamp. Even non-magnetic watches were stopped by being placed in strong fields, owing to Foucault currents generated in the moving parts.

Mr. BLAKESLEY inquired whether the instrument could be used in any position. He thought three observations would be necessary to completely determine any field.

Mr. STANSFIELD, in reply, said they used a pilot needle for showing the direction of the fields, and then placed the coil accordingly. The instrument could be used in any position, for the weight of the coil was only about 2 grammes, and did not greatly alter the tension of the suspension, which was usually about 300 grammes. A watch with a brass balance was uninfluenced by a field of 10 C.-G. S. lines, but seriously affected by one of 40.

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THE ELECTRIC RAILWAY SCHEMES IN PARLIAMENT.

JOINT COMMITTEE OF LORDS AND COMMONS.

The Joint Committee of Lords and Commons appointed to consider and report generally upon the Electric and Cable Railway Bills presented during the present Session, met for the second time on Thursday, the 12th. Mr. Stansfeild.

General HUTCHINSON, R.E., of the Board of Trade, said, in answer to Mr. Whitmore, that he had examined the various schemes referred to the Committee. They appeared to follow convenient routes. As to the motive power proposed to be used he had no doubt it would be sufficient for the traffic it was intended to deal with. He formed that judgment principally upon observation of the working of the City and South London Electric Railway. The present schemes were all of them better than the City and South London in regard to the size of tunnels or tubes, gradients and curves. The only suggestion that it had occurred to him to make was that where the tunnels passed under the bed of the river they should have double tubes or skins, an inner and an outer, as an additional precaution against the percolation of water in cases of accident. It would be an advantage if the tunnels were made large enough to admit the ordinary rolling stock of the country, instead of, as proposed, only 11ft. 6in. wide, but it would be a great additional expense. In regard to motive power he might mention that he had had occasion recently to inspect a tramway where the gradient was more than 1 in 14, and he found that the electric power was quite sufficient to take the car at that gradient.

Mr. STORY-MASKELYNE: If the heavy trains that now run on the Great Northern were passed on to these underground lines, have you considered whether electricity would be sufficient to move them unless you had very much larger power than is proposed to be used in these tunnels? It is a very important matter if you cannot work these heavy trains through the tunnels except at an enormous expense beyond what is contemplated.

WITNESS: The only knowledge I have on the subject is that some years ago there was a proposition to use a large engine with electric storage in it for working the trains on the Metropolitan Railway. I understand that in working out the details of that engine it was found to arrive at such an enormous weight that it became impracticable. The idea was therefore shelved.

Mr. J. H. GREATHEAD, engineer to the promotors, recalled, said, in answer to Mr. Gathorne-Hardy, that if the tunnels were made large enough to take ordinary rolling stock it would involve an additional expenditure of £100,000 per mile for construction alone, apart from other matters.

By Mr. STORY-MASKELYNE: Supposing the tunnels were large enough to admit the ordinary rolling stock it would make little difference in cost, whether steam or electricity was used as the motive power.

Mr. CRIPPS, Parliamentary agent for the London County Council, gave evidence to the effect that the Council had no objection to the schemes in the abstract, but wished to make certain recommendations in regard to them. One was that the tunnels should, instead of following closely under the course of the public thoroughfares, be made in straight lines from point to point or station to station. Another was that the tunnels should be made large enough—say 16ft. diameter instead of 11ft. 6in.—to admit ordinary rolling stock and through traffic to the main lines above ground in the event of junctions being hereafter effected. He did not suppose the Council would insist on these conditions if the enforcement of them would make the schemes, from financial or other reasons, impracticable. Another question which the Council had had under consideration was that of ultimate purchase. They considered that clauses should be inserted empowering the Council, as was already done in the case of the tramways, to acquire the lines by purchase after the lapse of a certain period—say, in this case, 60 years.

Mr. A. H. BINNIE, engineer to the County Council, was also examined, and he stated, *inter alia*, that, whatever the size of the tunnels, electric or cable power must be used. The use of steam locomotives would be out of the question.

By Lord THRING: No doubt if conditions are imposed which increase very much the cost of these lines, we may defeat the object we ourselves have in view in promoting cheap communication.

Mr. STORY-MASKELYNE: As to the practical working of these lines by electricity, could you work the heavy traffic—the large carriages that now run on our ordinary railways—with the same sort of installation that would be sufficient for carrying the light trains proposed by the promoters of these Bills?

WITNESS: What the difference in expense would be I cannot say, but the thing could be done.

Lord THRING: Have the County Council considered whether any protection is required in respect to the noise and nuisance that would be created by the electric installation at the terminal stations?

WITNESS: We are asking, should these Bills get to the Committee stage, that clauses shall be introduced bringing the railways under the ordinary Building Acts of the metropolis, which would be some protection to the public.

Lord THRING: I think that protection would only apply to the proper construction of the buildings. Would not the generating station create noise and rumbling which would be an annoyance to the inhabitants of the neighbourhood?

WITNESS: There would be a certain amount of noise and rumbling, but with modern machinery it is very slight. If it should be otherwise, the Companies, like other people, would be liable to actions for damage, and must pay for it.

Lord THRING: But if the Committee authorise the making of a particular generating station it is said there will be no legal remedy for any injury caused by the vibration and noise. Do you think it would be just, in a Bill authorising the construction of these railways, that compensation should be made payable to persons who prove that the noise or other effects of the construction injure their property?

WITNESS: No doubt everyone's property ought to be protected against injury in such a case, although personally I don't anticipate any injurious vibration in regard to these railways. There is very little vibration on the South London Railway: except at the stations where there is a little noise coming up the lifts, you neither feel nor hear it.

Mr. STORY-MASKELYNE: Are not the telephone wires affected?

WITNESS: I believe not in any way.

Mr. CHARLES HARRISON, Chairman of the Parliamentary Committee of the County Council, explained that the suggestions they had put forward were based upon consideration of the probable expansion of traffic and the development of electric science in the next quarter of a century. They were only in the infancy of these things now, and must look forward to the requirements of the future.

The Committee adjourned until Monday.

MONDAY, MAY 16TH.

On re-assembling on Monday Mr. W. H. PREECE, F.R.S., said: I am anxious to bring before the Committee the enormous growth of the electric railway system in the United States. Here in England the first electric railway was constructed in Blackpool in 1885. In the United States in 1884 there was only one road, but they have gone on increasing from year to year until now, when there are 436 roads equipped with 5,851 motor cars. An interesting fact connected with the working of railways in the United States is that there has been no death caused by any of these electric railways, whilst on the steam roads in New England alone there were 5,241 deaths, one half the victims being passengers, and the other half railway servants. I should point out that the great advance in electric railways in the United States has been due to the greater necessity in that country for such locomotion; especially in regard to what we would call suburban tramways. There are no municipal restrictions in that country, and their engineers are eminently practical. When a thing of this kind shows that it is paying they utterly disregard all æsthetical considerations. In fact, in the United States overhead wires are regarded as a mark of progress and civilisation. They do not care much about wires underground. The great reason why railways in the States have made such rapid progress is the fact that they have been a financial success. There is an excellent specimen of an American road at Leeds. I will hand in a complete list of all the electric railways and tramways in the United Kingdom. A great many experiments have been made both here and in America, in trying to work tramcars with batteries instead of horses. This has been done notably on the Barking-road of the North London Tramways and in the central district of Birmingham. The experiment is still in progress. In New York it has been a failure, and the overhead trolley wire has beaten battery traction out of the field. Underground systems of conduit and conductors, such as is in use at Blackpool, have also failed in the States. It was costly to instal and difficult to work, owing to water, snow, mud, and slush. A system—the Lineff—where the conductor is not exposed at all, is about to be tried on the Hammersmith and Kew Road. I have inspected electric railways in Rome, Paris, Florence, Antwerp, Vienna Brussels, Frankfort and Murren. This is all the evidence I propose to give as to the history and growth of the system.

By Viscount BARRINGTON: On all the railways I have been referring to the cars are of the same pattern as the tramcars to be seen in the London streets. None of the railways on the list I have handed in is a tube railway, except the City and South London.

Mr. STORY-MASKELYNE: Are there any in America?

WITNESS: Not one. In America the electrically-worked railways have proved so successful and have had such increased traffic that they have the term universally applied to them—"The factor of public satisfaction." The first reason for working railways by electricity in preference to steam is economy. I shall be able to show that there is no doubt about the economy. The weight carried, for instance, is reduced to a minimum. Inertia is small. Starting and stopping is easy. The power generated is centralised in one spot, and it is applied exactly where it is wanted. The most economical forms of boiler and of engine are available. The mode of working is safe to person and to car. There is no fear of explosion. The electric car is more controllable than a locomotive. It can be backed and sent ahead to make up for lost time, which is not the case with horses or cables, although it is with locomotives. With horses and cables you cannot back easily, and with cables you cannot go ahead. The electric system is flexible and elastic. The air in tunnels is not vitiated by unburnt gases or by the refuse of combustion of coal and coke. There is no smell nor smoke. The conditions in a tunnel are the most favourable to maintain electrical connections. There is no rain nor snow. It is an ideal place. I have no new authentic information as to the cost of the working expenses of these railways, but we may say roughly in regard to all of them that the cost per car mile comes out on the average at sixpence—that is, for a car which, when full, would weigh about ten tons and carry forty passengers. Failures, of course, there have been, and failures are inseparable from pioneer systems, especially when electrical. I have absolute faith in the future of electric railways.

By Mr. WHITMORE: The railways are to be worked on the block system. As a rule the trains have two motors, and any failure is generally due to one of the motors, in which case the other has to do the work alone, and does it, of course, more slowly.

By Lord KELVIN: I understand that for many months past there has been no failure on the City and South London line. Previously trains have been delayed for half an hour or so through the failure of one of the

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motors, but there are two locomotives that are working now with great satisfaction. Of course the weight of the locomotive must be strictly in accordance with the work it has to do. When I referred to lightness I was referring to the lightness of the cars, and, of course, there would be no tender necessary for coke or water.

By LORD KELVIN: The gradients we meet with in England are nothing compared with those to be dealt with in the United States. There is one place in Alabama, at a place called Nuttion Bridge, where the railway ascends something like 500ft. in one long gradient of 7½ per cent., which is 1 in 13¼. That is far beyond anything we have attempted in this country. It would require about 80 H.P. to ascend that gradient.

By Mr. STORY-MASKELYNE: The difficulty in working an electric railway is the enormous power required at starting.—There is room for improvement.

I suppose they might start the train mechanically without depending on their motor?—Yes.

Lord KELVIN: Does the electric railway cause any disturbance of the telegraph or telephone wires?

WITNESS: We have not experienced, up to the present moment, any interfering disturbance from the existence of the South London Railway; but there is an electrical disturbance that affects the whole of the electrical conditions of London, and it is noticed even at Greenwich Observatory. The records of the Observatory are affected by the working of the railway, and we also, in the Post Office, have been able to observe the alteration in the electric condition of the earth about London upon our service; but it does not interfere with our working, and therefore we attach no importance to it.

Does it upset your signals at all, or ring electric bells?—No, it is never strong enough for that.

Does it affect the telephones?—I have made many experiments to see if there was any disturbance of the telephones, and I can trace none.

Mr. STORY-MASKELYNE: Do you know if any considerable part of the energy of the rails is lost in the circuit?—I am afraid the loss is considerable. At the beginning the points of the tubes were metallically connected, but I think they are not now. It would certainly be difficult to work these railways with a complete metallic current; but if that could be done there would never be the slightest chance of any disturbance. The practical difficulty, however, of completing the metallic circuit on a railway is, as I have said, very great.

Would it not be possible to lay a thin copper sheet under the rail, and carry that through the insulation?—That is done at Leeds. I am not sure whether it is done on the South London.

Lord KELVIN: I understand the occupants of a house next the engine-room of the South London Railway complain of the house being made uninhabitable by the disturbance.

WITNESS: I can speak from some considerable experience on that question. The General Post Office our new building, where all our permanent officials have their quarters, has now in the centre of it four large engines that are used for working the pneumatic tube service of London. The engines are of 600 H.P. They are at work continuously day and night, and yet I am quite sure if you were to ask any official in the Post Office where the engines were he would tell you he did not know of their existence. Again, in the large building at St. Martin's-le-Grand, where all the letters are sorted, there is 1,000 H.P. used in producing electricity for the lighting of the place (we supply 10,000 lamps), and that causes no noise. This Committee might at the present moment be sitting over that engine-room with all the machinery going and not experience any disturbance at all. There are eight high-speed engines, and frequently five or six of them are going at once; in fact, it is just such a central station as would be required for working the proposed Waterloo and City Railway.

And the vibration proceeding from those engines is not inconvenient?—It is not perceptible.

How far from the engine-room is it not perceptible?—It is scarcely perceptible outside the engine-room. We have another central station at our Savings Bank Office in Queen Victoria-street. Close by our office there is the office of a firm of solicitors who complained of disturbance, alleged to be due to the vibration of our engines. We had a good deal of trouble over the matter, and ultimately found that the disturbance was not due to our engines at all. It was traced to the Metropolitan Railway, which runs under Queen Victoria street some 250 yards from the solicitor's office, whereas our engine-room is only 20 or 25 yards. In our investigations into that matter I found the most convenient instrument for testing the vibration of a building was a simple glow lamp. We have complaints as to smoke, and the British public have not yet learnt to distinguish between the vapour of steam and the black smoke of coal. We are now putting in a contrivance to enable us to burn anthracite, which does not give smoke. I think if we do not send up smoke the complaints as to mere steam vapour will not be so serious. The South London Railway is free from smoke, and I have not heard of there being any complaints as to steam vapour.

Would the electrical advantages on these new railways be affected by the question whether the tubes were the same size as those of the South London or much larger?—It seems to me that the tubes of the projected Waterloo and City Railway, 12ft. in diameter, are ample for such purposes as these railways are promoted to serve.

Do you think it would be a great advantage that the tubes should be made very much larger, so as to allow ordinary railway trains to pass through?—I think it would be a distinct disadvantage. These railways, it appears to me, are to be put down solely for the benefit of urban passengers—not for through passengers or goods—and the size of the tunnels on the proposed railways would be large enough. If the tubes were larger, the stations and the whole of the plant would have to be larger in proportion, and so the cost would be greatly increased.

Viscount BARRINGTON: Would there be any advantage in having the tubes of all the railways of an uniform size?

WITNESS: I do not see that it is necessary, as it is not proposed to connect the different lines.

By the Earl of LAUDERDALE: The average speed of working on the South London is about 15 miles an hour; on the City and Waterloo it will be about 20. It is proposed on these new railways to work on the block system, and to have intermediate blocking stations between the ordinary passenger stations.

By Mr. STORY-MASKELYNE: As it is impossible to tell what developments may come about in the future, it might be desirable to construct these lines on the same bases as to size of tubes, &c., although there appears no immediate necessity for doing so.

By Lord KELVIN: As the up and down lines are in separate tunnels, the danger of trains fouling the lines does not exist. The block system is easily worked on electric railways, and could be made automatic.

By Mr. STORY-MASKELYNE: I see no reason why the tubes, where they pass under the bed of the river, should have double casings.

Mr. ALEXANDER SIEMENS was called to speak specially as to the Great Northern and City Electric Railway, which was designed to carry through the Great Northern traffic to the City in Great Northern rolling stock. Whilst a South London train weighed about 70 tons, a Great Northern would weigh 180 tons. As Mr. Preece had already pointed out, a locomotive must have a certain weight—about 45 tons in this case—to acquire the necessary power to make such heavy trains go. His firm had gone carefully into that question. They could build electric locomotives of the necessary weight and power to start such trains of 180 tons, and run them over the line where the steepest gradient was 1 in 66. The dynamo electric machines had the good quality that they could exert very great power at starting. The fact that the trains weighed 180 tons constituted no difficulty in the way of working with electrical locomotives, because it depended simply on the motor having sufficient power to move the train, and there was no difficulty in getting 600 H.P. He had gone into the question of cost. Assuming that the journey from Finsbury Park to the City whould have to be done in 10 minutes, he found the cost of the motive power would be between 10d. and 1s. per train mile for 180 tons. That was a very ample allowance.

The CHAIRMAN: That is nearly double the train mileage on the South London?

WITNESS: Yes. That has come out at nearly 7d., but the charges there are still somewhat high. We think we could work the 180-ton trains at 10d.

The Earl of LAUDERDALE: At what rate of speed?

WITNESS: An average of about 18 miles an hour. In 1889, at the request of Sir John Fowler, I went into the question of working the Inner Circle trains by electric motors, and within the last few days I have gone into the matter again in the light of the experience we have gained on the South London. I found there would be an outlay necessary of about £150,000 to supply 20 electrical locomotives, conductors, generating stations, and everything complete to take the 14 trains that are running on the Inner Circle Railway at the speed they are now going; and then the cost per train mile would come out at about 8d.

The CHAIRMAN: How does that compare with the cost of the present system?

WITNESS: About the same. Perhaps the present cost is a little more.

Mr. GATHORNE-HARDY: Then there would be no great advantage?

WITNESS: No.

The CHAIRMAN: Do I understand that electricity is as applicable as steam power to heavy trains?

WITNESS: Yes, certainly; but the outlay for generating plant, conductors, &c, is very heavy—so heavy that it would not pay to run heavy trains by electricity unless they were very frequent; and of course that could only be done if there were sufficient passengers.

The Earl of LAUDERDALE: Ordinary locomotives could run at short intervals the same as the electric?

WITNESS: Yes; I don't see any difference.

Then if there was an increased number of passengers in the one case and it paid, the same thing would happen in the other case?—Yes; but when you have sufficient traffic to justify frequent trains, the electric power comes cheaper than steam power. It would not pay, for instance, to run heavy trains to Liverpool or Manchester by electricity with the present limited traffic, although, leaving the question of profit out of sight, it would be quite feasible to do so.

By the CHAIRMAN: The electrical trains would be easier to control than the steam. The motive power of electricity is better adapted than steam to the running of very light trains. As to the size of the tubes I think that for simple passenger traffic they ought to be made as small as can conveniently be done. I think the City and South London tubes are rather too small in diameter, and that 11ft. 6in. would be an improvement. I think the tunnels should be as small as they can conveniently be made, because of the important question of cost.

By Mr. STORY-MASKELYNE: As to the question of uniformity of diameter my private opinion is that it would be best to have the tubes all alike. At present there is no idea of connecting them, but it would be better not to exclude the possibility of its being desired in the future.

There would be no inseparable difficulty about securing such uniformity?—No.

If they were to be all of the same width, what would you say that that width ought to be?—I should say a little wider than the South London—say about 12ft.

It would not occur to you to suggest that they should all be 16ft. wide?—No, I think not. There are special reasons for it in the case of the Great Northern and City Railway, but I think in regard to the other lines it would make them unnecessarily expensive.

Lord KELVIN: What electric pressure would be used on these lines?

WITNESS: I believe that for the present the same pressure is contemplated as is used on the South London, viz., 500 volts; but in view of

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the greater length of the lines, I should say it would be better to employ 1,000 volts.

In that case would it not be better to have the currents overhead? Otherwise, in case of accident, would it not be dangerous if passengers were walking about in a tunnel when there was a current of 1,000 volts in the middle rail?—In case of accident the current would be cut off.

You are decidedly of opinion, all things considered, that 1,000 volts would be preferable to 500?—Yes. I am looking at it entirely from the standpoint of cost.

Would it not be as easy to have the conductor overhead as underneath the train?—Yes, and that was our original proposal on the South London line.

If 1,000 volts were used there would be some danger?—Yes; it is bad enough with 500.

That is, you might not be hurt by a current of 500, but with a current of 1,000 you would be seriously hurt?—That somewhat depends upon the individual. It would be safer, if circumstances would permit, to have the conductor at the top of the tunnel. The difficulty on the South London would be in regard to insulation, owing to want of space. The putting of the conductor in between the rails was more convenient in that instance.

Supposing a railway porter or signalman was to trip accidentally whilst in the tunnel, and fall across the rails, with the current of 1,000 volts passing through, what would happen?—It might depend on the state of his clothing.

Suppose it was very wet?—I think it would make him jump up.

You think he would jump up? Suppose his head struck the conductor?—As I have already said, a great deal depends upon the individual. Some can stand a great number of volts.

You think some would jump up; but would not a large proportion be killed?—Some might be killed. I should expect them to be burned.

Suppose it was to be ruled that where the conductor was on the ground the voltage should be limited to 500, and that where the voltage was more it should be compulsory to have the conductor overhead?—I think that would be a very good way of giving an alternative.

Mr. STORY-MASKELYNE: Does the Board of Trade require any particular voltage on lines in the streets?

WITNESS: I think they allow 300, but if you want more you can make special representations. I believe they will sanction 500.

If we insisted on a lower voltage, would that mean an increase in the number of stations?—It would be a question of money—whether it would pay better to put more generating stations, or to have larger conductors. It would mean great cost, anyhow.

But the difference of cost would not be prohibitive?—Oh, yes, it might be.

Do you know the amount of the difference it would make in the cost?—I could not say offhand.

Mr. GREATHEAD: In the case of the City and South London, the Board of Trade inspectors went thoroughly into the question of where the conductors were to be, the voltage, &c., and they inspected the line before it was opened to the public. They allowed us 500 volts, and we work with 500.

Mr: GATHORNE-HARDY: Would there be any difficulty in putting your conductors at the top of the tunnel?

Mr. GREATHEAD: Only that it takes away so much of the headway from the carriage.

Mr. CHARLES H. SCOTTER, general manager of the London and South-Western Railway, gave evidence as to the necessity of improved facilities for passenger communication between Waterloo and other parts of London. He believed the proposed electric railways to the City and Baker-street would go a long way towards solving the difficulty; and the schemes, on account of their comparatively small cost, would, he believed, be quite practicable.

Mr. W. N. COLAM gave evidence in support of the Hamptead and Charing Cross Cable Railway.

The CHAIRMAN intimated that the Committee would require no further evidence as to the desirableness of the routes of the proposed lines; and

The Committee adjourned until Wednesday.

WEDNESDAY, MAY 18TH.

On Wednesday, Mr. J. WOLFE BARRY, Engineer to the Corporation of London, was the first witness. He stated that, in conjunction with Col. Heywood, he had been requested by the Corporation to report upon the railways from a strictly public point of view. The first part of their report being descriptive, he would not touch upon it, as that side of the question had already been dealt with. The first question submitted to them was that of the depth at which these iron tubes ought to be placed; and their recommendation in that matter was that no portion of the railway tunnels should be less than 10ft. below the undisturbed surface of the London clay. In his judgment it was very essential that a clause to that effect should be inserted in the Bill, because the safety of the adjoining buildings depended altogether upon these tunnels being kept well down into the London clay. He thought the promoters of these schemes recognised that to a certain extent, and he believed the intention was to keep below that level. The reason why they should keep the tunnel below the London clay was that it was a stratum which was practically impervious to water; and, except for accidental depressions and cracks, which were very rare, and would not extend more than 10ft. below the surface, very little difficulty in tunnelling was experienced. Whereas, if they attempted to drive these tunnels in water-bearing strata, the whole problem was entirely different, and involved much more serious risks to property; and it was obvious that if a tunnel was not laid at a great depth below the road level, the houses adjoining and streets, 40, 50, or 60ft. wide, would be affected. The next point which the Committee asked their opinion upon was the diameter of the tubes, which was a most important question. There were two questions, the uniformity of gauge and the absolute size of the tunnels. Legislation with regard to this, up to the present time, had been somewhat haphazard. In the case of the City and South London Railway, the tubes, he thought, were intended originally to have a diameter of 10ft.; their Bill was introduced into Parliament as a cable tramway rather than a railway, and it was subsequently worked by electric motors. In the Act for the extension to Clapham, passed in 1890, this 10ft. diameter was secured. Last year a Bill was deposited by the same Company which proposed a diameter of 11ft.; that was not passed, but the Central London Railway Bill was passed with a diameter of 11ft. 6in. This year they had various Companies, proposing diameters of 11ft. 6in., 12ft., and 16ft. The Baker-street and Waterloo Railway proposed a 12ft. diameter, the City and South London 11ft. 6in., and the Hampstead and Charing Cross line 11ft. 6in.

By Lord KELVIN: He supposed the reason why the engineers recommended the smaller size was that they found the larger ones not suitable to curves and matters of that kind, and having regard to the question of rolling stock. If they had a very small tube, however, it resulted in a very high amount of air resistance. He would insist upon uniformity of tube, and would recommend that they should be made large enough to carry the ordinary rolling stock of the country. The tubes ought to be a little larger where the curves were short.

Continuing: He wanted to establish a minimum size. The third question was the adequacy of the proposed railways for the present and future traffic of London. They agreed that there could be no question that a very large traffic could be carried by these railways. At the same time they did not think that the lines could be expected to carry the traffic as easily and conveniently as ordinary railways. The fourth matter was the question of communication between the several railways proposed and existing railways. At present the proposals before the Committee, except in the case of the Great Northern and City Railway, which not only joined the Great Northern Railway system, but sought for running powers over a portion of their system, there was no connection with railways; they were in juxtaposition to existing lines, but not connected. The Corporation thought this question of junctions was one which merited the most careful consideration of Parliament. Then, as to the desirability of a central station at the Mansion House, their view was entirely endorsed by the Corporation; there was no doubt the Mansion House had many advantages for receiving and distributing the traffic of these railways; but, on the other hand, the site was a greatly congested spot. By the Bills under consideration three railways would have their termini or stations at the Mansion House, and at the busy times of the day each would develop a very large traffic. The traffic would not be spread uniformly over the day, it would be generally concentrated for about two hours in the morning and two hours in the evening; and although these railways would not require much vehicular accommodation, the centralisation of foot traffic might at times be found inconveniently large, when all the stations were working their full power between 9 and 11 o'clock in the morning, and from 5 to 7 in the evening. It was proposed in the Mansion House site that there should be a circular gallery and a booking office underground for passengers and lifts, and the public would also have the right to cross through these galleries to cross the roads. The City viewed that with some considerable alarm as a great concentration of traffic. The station would be constructed, as he apprehended, in the London clay by the use of shafts. But, in addition to that, the whole of the site was intersected by gas and water pipes of a very important character, and it would be necessary to construct a subway about 250 yards in length below the street, and into that subway would have to be laid a complete set of new gas and water mains before any of the old ones were interfered with. He should like to say that if these Bills went forward they ought to be adequate to carry the rolling stock of the country, and he considered that at present a break of continuity was proposed which approximated very nearly to a break of gauge. Looking ahead and at this subject from a broad point of view, these lines might be good lines in themselves if they were made a proper size, and as to the cost, he did not wish to quarrel particularly with the figures which he understood were indicated.

By the CHAIRMAN: The capital of the Waterloo and City line provided for a cost of £258 a yard. He would propose an extra cost. Supposing the extra cost of the tunnels varied as the square of their diameters, he did not endorse the idea that a 16-foot tunnel was required. On this principle the line he had mentioned would cost £314 a yard, or an addition of 22 per cent. on the total capital. The Hampstead and Charing Cross Railway treated in the same way would require an addition of 25 per cent. of the total capital. He thought even if the addition was considerably more it would be money well spent in the interests not only of the public but of the shareholders. A railway which was able to carry all the traffic of the country was, he thought, double the value of one which could only carry strictly urban traffic. Touching on the question of fares he mentioned that at present the urban fares of the Metropolitan District Railway were scarcely remunerative. Since the omnibuses and trams had been competing with them their remuneration had dwindled in a remarkable way, and they relied a great deal on their extension into the country. If electricity was to be the mode of working, it could just as well be applied in a large tunnel as a small tunnel. He did not think they could look forward to an electric railway working more quickly than the Metropolitan Railway, which was about 20 trains an hour, and on boat-race day perhaps they might reach 24 or 26 an hour. The trains of the District Railway frequently carried 400 passengers at certain times of the day, owing to people standing up in the carriages.

By Lord THRING: There was no place in the world where traffic required so much accommodation as London at certain times of the day. He thought if the suggestions he had made were carried out the schemes

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would be very much more valuable. He did not ask the Committee to throw out the Bills, as he thought it would be a great pity to abandon them; but the connections with existing railways was a most important point, which he thought ought to be provided for if the Bills went forward. He admitted that if carried out they would greatly relieve the congested traffic of the streets.

Sir DOUGLAS FOX, Engineer to the Hampstead and Great Northern and City lines, was the next witness. He drew attention to the fact that the question of the introduction into an important city of a subsidiary system of lines had been very fully considered in New York, resulting in the introduction of an auxiliary system of overhead railways. The principle in the two cases was the same. The overhead lines were not so constructed as to accommodate the rolling stock of the main line, being neither of sufficient strength nor having curves of a requisite radius. These lines carried at the present time about 200 millions of passengers per annum, entirely independent of direct junction with the existing main lines. The question had also been considered in Liverpool, where they had an overhead railway six miles in length, running through Liverpool from end to end; and there this same question cropped up, as to whether it was necessary or desirable to incur the increased cost of making the line suitable for carrying the ordinary rolling stock, and the conclusion had been that it was not desirable. When the Inner Circle scheme first came before Parliament, it was proposed that it should be an inner circle with junctions. The large number of outside trains called into the system introduced irregularities and delays. Whilst they might be profitable to the companies, he did not think they increased the efficiency of the service. It had been said that these trains could not compete with omnibuses, but he ventured to think one reason for that was the bad ventilation. The Great Northern and City Company proposed to make their diameter 11ft. 6in., but with an increased diameter on the curves of 12ft. If the tunnels could be made of sufficient diameter to carry main line stock at the same cost, the question of additional cost would hardly arise. Mr. Barry had said that the cost of the increase was the square of the diameter of the tunnel; but if they worked it out they would find that a 12ft. tunnel worked out to £144 and a 16ft. tunnel to £256, which was very nearly double. The cost of the Inner Circle, taking the whole of it, might be put at not far short of £1,000,000 a mile. The estimated cost of the Great Northern and City Railway, with a 16ft. tunnel, was £650,000 a mile; the estimated cost of the Hampstead line, which had a 11ft. 6in. tunnel, was £370,000 per mile.

The CHAIRMAN: Do all these equally include rolling stock?

The WITNESS: Yes.

Lord THRING: Do you mean these sums would mean putting the railways in actual working order?

The WITNESS: Yes, the total capital expenditure, stations, rolling stock, line, and everything. He was convinced that this difference of cost which Mr. Barry proposed for those lines which were intended as purely passenger lines, would be prohibitive, and it would not be possible to raise the money nor to construct those lines in such a way as to take the main line traffic of the large companies. The one exception was the Great Northern and City scheme. He did not see how it would be at all possible to utilise the Hampstead line, supposing they could make junctions with the four existing lines, connecting at one end with the South-Eastern Railway and at the other end with the London and North-Western, Midland, and Great Northern Companies. For a railway which was specially designed for running three-minute trains for local traffic, it would be to introduce confusion and delay, which would practically destroy the utility of the railway as a railway for local traffic. With reference to the Great Northern and City Railway, it was under the consideration of the Committee because it was proposed to work it by electricity, otherwise it was an ordinary extension of an existing railway system to a railway station in London. It was promoted because the Great Northern Railway district, which was one of the finest suburban districts anywhere near London, had only two accesses to London, one over the Metropolitan Railway through King's Cross, and the other over the North London Railway to Broad-street, and both at this moment were completely congested. The trains running at the busy times of the day carried far more passengers than they ought to carry; and yet there was a constant outcry from all persons interested in these particular suburbs that they were not properly served. This scheme was to enable the Great Northern to project an entirely new system of trains of their own from this district, and new districts which they proposed to open up to this station in Moorgate-street. They had considered very carefully with Sir Henry Oakley the diameter of tunnel. If they had adopted the smaller tunnel, they would have had to go to Finsbury Park in order to make a proper exchange station, which would have involved an additional length of at least one mile of railway tunnel. It would have given them a very expensive underground station at Finsbury Park, instead of an open one at Drayton Park; and they would have had an exchange traffic by hydraulic lifts, instead of as at present by ordinary means. They would have had also to provide electrical plant for an additional mile of railway, quite unnecessarily, as the Great Northern Company were willing to run into Drayton Park, and they strongly objected to duplicating their line between Finsbury Park and Drayton Park. It so happened that the conditions surrounding the proposed station were such that they were able to make a line with a comparatively easy gradient from an ordinary junction of the Great Northern system. Another very important consideration was that the Great Northern were willing to allow their suburban trains to run over their line, and their Company thus would be saved the cost of supplying their own rolling stock. They had found that in this particular instance it would be as cheap to make a line to join the Great Northern with an ordinary junction and a large tunnel as it would have been to make a smaller tunnel with the greater length to the exchange station. The exchange station was generally better than a junction. With regard to easements under property where the property was not affected, they had always been taken to represent a considerable value; therefore, if the railways were carried direct from point to point the compensation, in his opinion, would be very large. He could not understand what had been said about taking the subsoil out of the streets. The public would be very great gainers by the companies taking the subsoil. At present it made no return to the rates, but as soon as these railways were made it would be rated, and the streets would become very valuable property. Neither the omnibuses nor the tramcars paid anything for their rights of running over the surface of the streets; whereas the railways, which did not affect the traffic, were going to pay a very large amount to the rates. It had been proposed by Mr. Barry that the depth of these tunnels should be fixed 10ft. below the undisturbed surface. He thought that, from an engineering point of view, that proposal was unworkable. With certain properties the owners might ask that such a clause might be inserted where the depth of the clay was low.

The CHAIRMAN: Would you propose that there should be no such limitation?

WITNESS: Yes; I do not think it is necessary.

By Lord STRAFFORD: He thought the tunnels would be out of the clay in some places. He did not come there as an electrical expert, but he would like to say that the Liverpool Overhead Railway Company, which had already been referred to, after considering tenders for steam and electricity, decided upon adopting electric traction for their line.

By Lord KELVIN: He personally should prefer electric traction. If the gradients were not too severe electric traction would be more economical than the rope traction, he thought.

Mr. W. R. GALBRAITH, Engineer to the City and Waterloo, and Baker-street lines, was then examined, and said with regard to the advisability of a junction of the Waterloo line with the London and South-Western Railway, that if an underground railway was made between the City and Waterloo, a junction with the London and South-Western Railway at Waterloo was impossible. He did not know where such a junction could be made, and any new line from the London and South-Western Railway to the City which joined Waterloo would be practically useless, because unless a train were split up at some point south of Waterloo, and a portion run into Waterloo and a portion into the City, it would be no use.

By Lord KELVIN: Tubes 12ft. in diameter were quite as good as 11ft. 6in. tubes for passenger purposes. He did not think there was any great merit in making the diameter of the tubes identical.

Mr. F. HUNTLEY was then called as a witness. He considered the proposal that the subsoil should not be allowed to be used without compensation being made a most objectionable one.

The Committee then adjourned.

LEGAL INTELLIGENCE.

Western Counties and South Wales Telephone Company v. Bournemouth and District Electric Supply Company.

In the Chancery Division on Friday last, the case of the Western Counties and South Wales Telephone Company v. Bournemouth and District Electric Supply Company, came before Mr. Justice Chitty, in the form of a motion by the plaintiffs, asking that a writ of sequestration should be issued for an alleged contempt of Court committed by the Bournemouth and District Supply Company, in wilfully disobeying an order of the Court, dated April 8th last, directing that the defendants should be perpetually restrained from working or using their electric lighting system, apparatus, and work, in the town and neighbourhood of Bournemouth, in such a manner as to injure or interfere with the plaintiffs' exchange system, and in particular from causing or permitting injury to the plaintiffs' system either by induction or leakage, or from any other cause connected with the defendants' inductors.

Mr. FARWELL, Q.C., who appeared for the plaintiffs in support of the motion, said this was a most important case for his clients, as they could not work their telephones in a proper manner after the defendants had turned on their electric current.

Mr. BYRNE, Q.C., on behalf of the defendants, applied that the case should stand over for a week. He was not at present in a position to say anything about the matter.

Mr. FARWELL said the telephones were absolutely useless, and, therefore, he asked that the defendants should give an undertaking not to use their electric light until next week.

Mr. BYRNE said when the motion was before the Court on a previous occasion the defendants were directed to put their wires underground, and they had done so.

Mr. FARWELL remarked that this was a case in which one of the companies must suffer the inconvenience of having their system practically stopped. He submitted that the plaintiffs ought not to be asked to stop their works. He wished to point out that the electric light was used for lighting, not the town, but some private buildings. The telephone system was of more importance to the people of Bournemouth than the electric light. If the defendants were not put under an undertaking not to use their electric light for a week, he would ask that they should not start their current until eight o'clock at night; and that an independent gentleman should go down to see what was being done, and file an affidavit to be used next week. He suggested that Major Cardew, of the Board of Trade, should be asked to inspect defendants' system and make a report.

Mr. BYRNE said he could not give any undertaking, as at present he did not know the whole of the facts.

His LORDSHIP said Mr. Farwell had done his best for his clients but he (the learned judge) could not place the defendants under any undertaking. The motion would stand over till this day (Friday).

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Love v. St. James and Pall Mall Electric Light Company, Limited.

In the Chancery Division of the High Court on Saturday, before Mr. Justice Stirling, a motion in the action of Love v. St. James and Pall Mal-Electric Light Company, Limited, came on for judgment.

His LORDSHIP said that the motion was one for interim injunction to restrain the Company from building, at their new central station in Carnaby-street, in such a manner as to interfere with the rights of the plaintiff for light and air to premises of which he was the owner. Since the 29th February communications had been passing between the parties, and so early as the 17th March the plaintiff had represented that the elevation of the proposed new front wall would be two feet higher than the height of the old buildings which it would replace, and that this would be a great injury to his property. The architect to the defendants replied that the plaintiff was in error in supposing that the new building would exceed the height of the old, and would cause any substantial deprivation of light. The defendants maintained this position and attitude until the action was brought, and this motion was made. It had since appeared that the plaintiff was right, and that the new building would have been two feet higher than the old, and thereupon the defendants gave an undertaking, and an arrangement was come to by which the action was stopped, and all that had now to be dealt with was the costs. His lordship thought that the result showed that the plaintiff had been justified in bringing his action, and that the action was reasonable. The plaintiff, on April 13th, accepted an undertaking from the defendants that they would not build otherwise than with certain altered plans, which they then exhibited; and thereupon the action came to an end, except upon the question of costs. In these circumstances the question to be decided was whether anything the plaintiff had done was so unreasonable that the Court ought to deprive him of his costs. His lordship thought not. He thought that the plaintiff had reasonable grounds for bringing his action because of the defendants' architect persisting, down to the date of the action, in his erroneous view as to the height of the old buildings. He therefore held that the general costs of the motion should be borne by the defendant Company.

An order was made accordingly.

Electric Arms and Ammunition Syndicate (Limited) v. Pooley

This was an action before Mr. Justice Grantham and a common jury to recover the sum of £83. 0s. 6d., calls on two shares in the above syndicate, which the defendant alleged he was induced to take by statements in the prospectus, and which he pleaded had turned out to be false; and he therefore asked to have his contract rescinded, or in the alternative he claimed damages for misrepresentation.—Mr. Willis, Q.C., was leading counsel for the plaintiff syndicate, and Mr. Jelf, Q.C., for the defendant.—A long legal argument took place on the first day as to whether the defendant had any legal defence, and in the result his lordship decided to hear evidence. Accordingly, on the second day the defendant himself went into the witness box, and, having given his evidence and the question of his legal defence having again come up for discussion between counsel, the jury asked his lordship whether the case could not be stopped, as they had made up their minds that the defendant had acquiesced in all that the syndicate had done, and that, therefore, he could not claim against the syndicate, as he was himself a member of that syndicate, and to that extent jointly responsible for the actions of its members, including the Directors.—His lordship, after consultation with counsel, found for the plaintiff syndicate with costs, and agreed with the jury that there had been no fraud on the part of the Directors, but that the prospectus was issued in good faith, and was thoroughly believed in by them. There was, therefore, no evidence to support the charge of fraud which had been so freely made by the defendant. The main feature of the action was the evidence which went to show that the chief difficulty experienced by the syndicate was the discovery of a battery suitable for firing small arms.

Hopkinson v. The St. James and Pall-mall Electric Supply Company (Limited).

Application was recently made by the plaintiff in this action for answers to a set of fourteen interrogatories by the defendant Company's engineer, and the Chief Clerk decided that the Company could not be required to furnish the answers. The plaintiff on Monday appealed against this decision, which was, however, upheld by Mr. Justice North, excepting as regards the first interrogatory, which required the Company to say whether or not their circuits are arranged in the manner described in the second claiming clause of the plaintiff's specification.

In re the International Cable Company (Limited).

In Chambers on Monday last, the question as to the party liable for the costs incurred in the inquiry as to the amount of fees to be paid to the Directors for services rendered between the date of the presentation of the petition for winding-up and the date of the winding-up order (a period of about six months), came before Mr. Justice Stirling; and in the result his lordship ordered that the Directors were simply to be paid with the other creditors of the Company, and he also directed that Sir Alexander Armstrong's costs of this application be added to his claim.

On Wednesday, in the Court of Appeal, the decision of Mr. Justice Stirling in the action of the International Cable Company (Limited) v. Suren and others was mentioned; and his lordship's judgment being considered by the appeal judges to be irregular in its language, as it left some doubt as to the disposition of a sum of £250, it was referred back to his lordship for amendment.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May 7*, 1892.

Rumoured Electrical Manufacturing Consolidations.—During the past week rumours have again been afloat of the coming combination of the Westinghouse Electric and Manufacturing Company and the Siemens and Halske Electric Company of America. It has been emphatically asserted on good authority that such a combination was about to be made, but New York parties connected with both of these companies have denied the report as utterly false.

The Western Union Company and the Telephones.—The annual meeting of the stockholders of the Metropolitan Telephone and Telegraph Company, the organisation which operates the telephone system of New York City, was held this week. Among the Directors elected were Thos. T. Eckert, Geo. J. Gould and Norvin Green. This merely serves to show what an intimate business connection there is between the telephone business of this country and the business of the Western Union Telegraph Company.

The General Electric Company.—The General Electric Company, the result of the Thomson-Houston and Edison combination, has been formally organised. The election of the new officers took place in Boston on Tuesday of this week, and resulted in Mr. C. A. Coffin being elected president, and Mr. Eugene Griffin vice-president and general manager, with Mr. Samuel Insull as second vice-president.

The New Edison Telephone Patent.—The telephone patents, about which rumours have been in circulation for three weeks, were issued on May 3rd. These are three patents applied for by Mr. T. A. Edison on July 20th and April 20, 1877, and were assigned by him to the Western Union Telegraph Company; that Company in turn disposed of them to the American Bell Telephone Company. It turns out that the patents are the same as those which were granted to Mr. Edison in nearly all European countries in 1877. It is generally admitted by American authorities that the claims of the patents, or a part of them, are very broad, and that if they can be sustained they will give the Bell Telephone Company an extension of its present monopoly. The question arises, however, as to the validity of the patents, since the foreign patents for the same invention had already expired when these patents were granted. How the matter is viewed on this side of the water may, perhaps, be best gathered from the following extracts taken from an article in the *Electrical World*:—"The case may then be summed up as follows:—According to our laws a United States patent expires with the date of expiration of the shortest termed foreign patent: everybody knows this law when they make application. Edison has, according to the requirements of the office, stated under oath that this invention was the same as that patented by him abroad; there can therefore be no question raised about its being a different patent; that 'trick of the trade' which is sometimes made use of to evade this law cannot therefore be made use of in this case. . . . But the question arises how the 'letter of the law' can be applied in case the United States patent is not issued until after this term has expired. This appears to be the first case of the kind on record. . . . The Bell Company may put in the plea that they have, through no fault of their own, been deprived of the patent protection for this patent for 15 years, and that they ought, therefore, to be allowed protection for 17 years from date. . . . But even admitting that the law could be twisted so as not to make the patents invalid, there still remain other unexpired foreign patents for this which will expire shortly, and which, according to the law, will make the United States patents expire very soon. No amount of argument can change this, unless the law be changed completely. The latter is a possibility. Edison has already expressed himself as dissatisfied with this law, which has affected him unfavourably before, and he wishes to have it changed. This attempt has been made before, but the Supreme Court has decided in favour of the law in all the cases. There is no telling, however, whether this wealthy and powerful Company, who have accomplished so

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much in the Courts already, might not prove to be more powerful than the Courts or Congress, and gain their point by some means. Congress may be appealed to, and if it wishes it can do what it pleases, or whatple ases the Company, but it is very questionable whether the Company would succeed in this way; it would be an expensive proceeding. But they have been so successful in the Courts that they may feel encouraged to try anything, without regard to principles, law, or equity. We have been suffering for years with a very unsatisfactory telephone system, operated purely for money, without any regard for the kind of service. In other civilised countries the Government has stepped in, here it has not; and it is a question now what the Government will do when it gets a chance to relieve the public of a most objectionable monopoly."

CORRESPONDENCE.

AN ELECTROLYTIC EXPERIMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 28 you extract from *La Lumière Electrique* an account of an experiment "due to Herr Arons, and shown by him to the Berlin Physical Society." It is the rotation of a copper cylinder, under the influence of electrolysis, dissolving one side and depositing on the other. Now, doubtless, Herr Arons discovered this for himself, but, none the less, the discovery is not "due" to him. It was discovered by myself, and included in a patent of mine, No. 4,454 of 1881, where I described a meter working on that principle: "I construct an electrolytic cell with a pair of electrodes, and mount between them upon suitable bearings an 'induced electrode' in the form of a cylinder, so that it can rotate freely when the deposit on one side and solution on the other alters its centre of gravity." I gave a drawing of the apparatus, with contrivances for directing the action upon the most effective parts of the surface of the floating cylinder, *i.e.*, the ends of the horizontal diameter.

I had discovered the fact and used it experimentally many years earlier in the form of a disc rotating in this manner between two electrodes.—Yours, &c., JOHN T. SPRAGUE.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—Our advertisement columns contain an announcement that the Dundee Gas Commissioners are prepared to receive tenders for the execution of the following six contracts in connection with the proposed supply of electric light to Dundee under Provisional Order:—1, boilers; 2, steam piping, &c.; 3, steam engines; 4, dynamo machines; 5, accumulator batteries; 6, street mains. Tenders are to be delivered to Mr. T. Thornton, clerk of the Commissioners, by the 31st inst.

——— Tenders are invited by an announcement in our advertisement columns for complete machinery for 100 incandescent lamps for the existing power, packed and put f.o.b Birkenhead or London. Tenders are to be sent to the Indentors Union (Limited), 4, Bury-court, St. Mary Axe, E.C.

——— Tuesday next, the 24th inst., is the day fixed for sending in tenders for the Glasgow contract. (See advertisement on page xix.)

TENDERS ACCEPTED.—The following tenders were received for the Bristol work (see *The Electrician*, May 6, p. 4). (1) Supply, delivery, and erection of steam alternators and steam dynamos:—

India Rubber, &c., Co. (Ltd.) (continuous only)	£21,090	0	0
W. T. Goolden and Co.	20,087	0	0
Brush Electrical Engineering Company (Limited)	19,495	0	0
Electric Construction Corporation (Limited)	16,175	0	0
Blakey, Emmott and Co.	15,954	0	0
Paterson and Cooper	15,826	0	0
Mather and Platt (Limited)	15,434	0	0
Crompton and Co. (Limited)	15,141	0	0
Johnson and Phillips	14,357	0	0
Woodhouse and Rawson United (Limited)	14,327	0	0
Latimer Clark, Muirhead and Co.	14,053	0	0
Siemens Bros. and Co. (Limited) (accepted)	14,011	0	0
S. Z. de Ferranti (Limited) (alternators only)	12,687	0	0

(2) Supply, delivery, and erection of boilers and accessories:—

E. Finch and Co.	£10,500	0	0
Hawksley, Wild and Co.	9,723	0	0
J. Thompson	9,500	0	0
Newall and Co.	8,999	9	6
Fraser and Fraser	8,614	0	0
Woodhouse and Rawson United (Limited)	8,063	10	0
Oldham Boiler Works	8,060	0	0
Yates and Thom	7,665	0	0
R. Taylor and Sons	7,504	0	0
Tucker Bros. (accepted)	7,300	0	0

——— Messrs. Crompton and Co. (Limited) have secured the contract from the Hull Corporation for the construction and laying of electric mains in the streets in the area prescribed by the Provisional Order. The work will be commenced at once, Mr. B. H. Jenkinson, who has recently completed the Southampton work, having the management of the contract on Messrs. Crompton and Co.'s behalf. The tender amounts to about £8,000.

——— The following tenders have recently been accepted for the Glasgow lighting work:—

Half-inch insulated cables and triple potential leads—W. T. Henley's Telegraph Works Company (Limited).
Quarter-inch insulated cables—India Rubber, Gutta Percha, and Telegraph Works Company (Limited).
Copper-strip—Elliot's Metal Company (Limited).
Excavating trenches and laying electrical conductors—Mr. W. Pollok.
Insulators—Messrs. Stiff and Sons.
Storage cells—Crompton-Howell Electrical Storage Co. (Limited).

THE ELECTRIC LIGHTING OF KILLARNEY.—The contract for the execution of this work has been obtained by the Brush Electrical Engineering Company (Limited). It is proposed to replace the 2,000 gaslights in use in the town with incandescent lamps, and the public lights with arc lamps. For this purpose £6 per Cent. Debentures of £10 each to the amount of £3,000 are to be issued. Underground mains will be used. Mr. Charles E. Leahy, Tralee, has negotiated the contract, which, the *Cork Examiner* learns, has been concluded on very favourable terms.

SALES BY AUCTION.—Messrs. Wheatley Kirk, Price, and Goulty announce in our advertisement columns that they will sell by public auction, on Tuesday next, the 24th inst., the valuable freehold land and buildings known as the St. James' Iron Works, St. James' End, Northampton, lately in the occupation of Messrs. Allchin, Linnell, and Co.; and on the three following days the entire contents of these works, comprising the modern plant and machinery, the stock of new engines, boilers, and agricultural and other machinery, and the engineering stores. Further particulars and catalogues may be obtained from the Auctioneers, 49, Queen Victoria-street, E.C.

SOUTH OF ENGLAND TELEPHONE COMPANY (LIMITED).—A meeting of the members of this Company is to be held at 5, Moorgate-street, E.C., on June 9th, at 2 p.m., for the purpose of receiving an account of the winding-up.

NEW PORTABLE ELECTRIC LAMP AND POWER SYNDICATE (LIMITED).—A meeting of the members of this Company (in voluntary liquidation) will be held at 11, Abchurch-lane, E.C., on June 22nd, at 12, to receive the liquidator's accounts.

MESSRS. KING, MENDHAM AND CO.—This firm have appointed Mr. W. B. Allison, 12, Fenchurch-st., E.C., their sole London agent.

THEATRE VENTILATION.—The ventilation of the theatre in the Musical and Dramatic Exhibition at Vienna has been carried out by the Blackman Ventilating Company (Limited), of 63, Fore-street, E.C., by means of a Blackman fan 72in. in diameter, driven by belt from a motor, and blowing in fresh air under all parts of the ground floor. The impure air is removed by eight electric Blackmans, distributed in various parts of the house. The current driving these fans is at a pressure of 150 volts, and at the opening of the Exhibition on Saturday last the Company's engineer (and the inventor of the electric Blackman) was presented to the Emperor during his inspection of the building.

COUNTRY HOUSE LIGHTING.—Rookwood, Llandaff, the residence of Sir Edward Hill, K.C.B., M.P., is being fitted by Messrs. Drake and Gorham for lighting throughout with electricity. A 7 H.P. gas engine will drive an 8-kilowatt dynamo, and power will be transmitted a considerable distance for actuating a pump.

MESSRS. POOLE AND WHITE (LIMITED).—Mr. T. G. Poole has resigned his position as Managing Director and Secretary of Poole and White (Limited), but retains his interest inthe Company.

ROYAL MILITARY TOURNAMENT.—The electric lighting of the Royal box and the officers' quarters and offices at this popular show has been carried out by Messrs. Woodhouse and Rawson United (Limited), Epstein accumulators of the "country house or private installation" type being used as a reserve. Two balloon lights, and also "Scott's Signalling Lantern" by which the Morse signals are flashed, have also been provided by this Company. The whole of the work was carried out in three days.

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PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

April 30, 1892.

8,165. F. V. ANDERSEN. Catford. Improvements in electric meters.

8,196. B. DEAKIN and W. L. SPENCE. Manchester. Improvements in arc light poles or masts.

8,211. M. H. SMITH and T. P. WILSON. London. Improved means for stopping or controlling electrical railway and tramway engines or carriages.

8,212. M. H. SMITH and T. P. WILSON. London. Improved means of holding and supporting electric conductors or otherwise, ropes or bars.

8,213. M. H. SMITH and T. P. WILSON. London. Improvements in coupling electric conductors and like wires.

8,222. W. C. RECHNIEWSKI. Paris. Improvements in dynamo-electric machines and motors. [Date applied for under Patents Act, 1883, sec. 103, October 31, 1891, being date of application in France].

May 2, 1892.

8,242. F. A. HASELWANDER. Manchester. Improvements in and connected with electrically propelled vehicles.

8,258. M. H. SMITH and T. P. WILSON. London. Improvements in carrying or supporting electric collectors.

8,265. W. H. INGALL. London. An improved globe or shade holder for electric, gas, or other lamps.

8,267. F. T. HOLLINS. Leytonstone. Improvements in electrical circuit arrangements and apparatus for telegraph message signalling.

8,268. G. S. GRIMSTON and A. H. DYKES. London. Electrical steering gear.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

6,485. GRAVIER. Dynamo-electric, &c. machines.

6,730. MORDEY. Dynamo-electric machines.

8,323. GOLDSMID. (Riatti). Thermo-electric apparatus.

9,291. BISHOP. Electric arc lamps.

9,734. ALDRED. Dynamo-electric machines.

10,082. JABLOCHKOFF. Voltaic batteries.

10,256. KING AND MENDHAM. Electric bells.

20,864. HODGKINSON AND THOMPSITT. Electro-medical coil and battery.

1892.

871. LAKE. (Brooks). Electric cables.

4,764. LAKE. (Hammond). Electric wire insulators.

4,773. REDFERN. (Bergmann). Electrical conductors.

4,816. FAIRWEATHER. (Phillips). Electrical cables.

4,961. MUIRHEAD. Electrical slide resistances.

5,096. SILKMAN. Printing telegraphs.

COMPANIES' MEETINGS.

West India and Panama Telegraph Company (Ltd.).

The thirtieth ordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Tuesday; Mr. C. W. Earle in the chair.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the minutes of the last meeting, which were signed as correctly entered.

The CHAIRMAN then said: Gentlemen, before dealing with the business proper of this meeting it is my painful duty to announce to you that one of those whose names are on the list of this report as a Director of this Company, is now no more. Our esteemed colleague, Mr. William Ford, died on Saturday last. He was present at the meeting which settled this report on the 4th inst., and he was then in his customary health and in possession of his usual mental vigour and spirits. We little thought then that we were seeing him for the last time. Mr. Ford has been very closely connected with this Company, not only as a Director, but also before he was a Director, for he was Chairman of the committee of shareholders which was appointed in 1873 to inquire into the then position of the Company; and it was on the recommendation of that committee that this Board was formed in the beginning of 1874. Since that time, now nearly 18½ years ago, Mr. Ford has continued, without intermission, to take an active part in the administration of your affairs. His keen and trained intellect, combined with his legal knowledge, made him a very valuable adviser to the Board on many intricate questions, while his high personal character and cheering influence in the face of difficulty secured for him the esteem and regard of us all. His death is a very great loss to the Company, and to his comrades on the Board a source of very sincere personal sorrow. I presume, gentlemen, that you will, as usual, take the report as read. I do not think that any shareholder who was present at the last general meeting in November, or who had read the report presented to that meeting, can have been surprised at the result of the half-year's working which we lay before you to-day. Both in that report and at that meeting full prominence was given to the serious effect upon our revenue that was being produced by the—we may say—unjustifiable competition that had been established in the French Islands of Martinique and Guadaloupe in our system; and when I use the term "unjustifiable," in speaking of this competition, I refer to the conditions of the telegraphic business of the field which the French Company have elected to invade. We who have carried on the telegraphic service of that field for some 22 years know how insufficient the telegraphic requirements of that region are to maintain one Company in even fair prosperity. Those requirements have been fulfilled practically at the cost of the shareholders of this Company, for they have never received anything approaching to a fair return on the capital invested in the enterprise. The only consolation I can express for the present circumstances—and it is but a poor one—is that our French rivals are suffering more from this competition which they have concocted than we are. Their traffic from Guadaloupe and Martinique we know must be very small, and they do not get it all even in those two French islands, where we are in active competition with them; and when you look further down the line to Paramaribo and Cayenne they have stations which are very unproductive indeed. In the Brazils we know that their traffic has hitherto been quite insignificant, and how they can pay their working expenses with the revenue they have apparently at their command, I am at a loss to state.

A SHAREHOLDER: Do they have a subsidy from the French Government?

The CHAIRMAN: Not from the French Government, but they get it from some of the Colonies. Turning now to the revenue account for the half-year, there is, as usual, but very little scope for remark with respect to the items on the debit side over which the Board have any control, The expenses under Abstract A. show an increase of £62, almost entirely attributable to some additional legal expenses over cable contracts and some additions to postal and stationery account. Under the head of Abstract B., there is a diminution from various causes of £546. There is a very satisfactory omission from among the debit items in that abstract, and that is that there is no charge this half-year for the hire of sloops during interruptions of cables. This is the first time, I think, that we have presented you an account without a charge under that head, and it is also the first half that I can remember in which we have received our subsidies in full—that they have not been subtracted from on account of interruptions. The fact is that during the half-year there has been no interruption at any station of the communications. On balance there is a diminution of expenditure under Abstracts A. and B. in comparison with that of the corresponding period of 1890, of £484. Abstract C., however, is not so satisfactory. It must be remembered, however, that we compare with an exceedingly low account in the preceding year—only £9,155—and also that the cost of cable since that time has increased by about 50 per cent. We have had a good many heavy repairs during the period of the report, but I find that the cost of repairs charged to revenue in the year 1891 does not exceed—is rather below—the average of the cost of repairs for the past ten years, although cables are so much more expensive now than they were. I may tell you that the average cost of our cable repairs charged to revenue in the last ten years has been £26,174 per annum, while for the year 1891 the costs were £24,900; so we are below the average, although in this second half-year it seems rather a serious increase. The sum of £2,119, which has been charged to reserve, represents the cost of renewing a considerable length of the St. Croix-Ponce cable. We have always charged these renewals of long lengths of cable to reserve, and on the present occasion we have followed that precedent. The laying of the new cable between Trinidad and Demerara completes our duplications, I hope. We have already had some advantage out of this, for the old Demerara cable has interrupted during the half-year recently, but owing to the duplicate connection the communication was kept up. I hope now that we may rest from further duplications, for there is no part of our system that we think requires duplications. I wish I could say we can rest and be thankful, but I am afraid that the thankfulness part will not be permanent. I am happy to say that we issued our £30,000 of debentures without incurring any expense for commission or discount, and the cost of the operation was confined to the legal and stamp expenses, printing, and other sundries which will appear in the next account. At our last meeting we were somewhat buoyed up with the hope that the sugar crop of the West Indies was going to be very flourishing this year, but I am sorry to say that that has turned out rather disappointing. The weather in the principal sugar-growing Colonies has not been propitious, and I am afraid that our West Indian friends are not having a good time of it. That re-acts to a certain extent on us. We may, at the same time, hope for a gradual increase in the amount of business we do on account of the reductions, though I am not very sanguine on that point. Hitherto reductions in the tariffs have been followed by a decrease in the number of words sent; and it appears to me that in countries like the West Indies, where you have got a very limited number of the population who employ the telegraph at all the reductions, no matter how great they may be, will not be productive of any great increase in the number of words sent. It is only the leading merchants there who employ the telegraph. You have not a population of the Anglo-Saxon race, which is constantly rising into positions where the telegraph is used. I now propose—

"*That the Directors' report and accounts to the 31st of December, 1891, submitted to this meeting, be and the same are hereby received and adopted; and that, as recommended by the Board, a payment of 6s. per share on the first preference shares, 6s. per share on the second preference shares, and 6d. per share on the ordinary shares, be and the same is hereby declared.*"

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Sir JAMES ANDERSON: It is my duty to second the motion, and I cannot do less than add my testimony to the words which have fallen from the Chairman respecting the loss of our colleague. I think you all know that in Mr. Ford we have lost a man who did not spare himself or his time in promoting the welfare of the Company; while his legal knowledge was also at our disposal, and we could rely on a man of much intellect and thorough knowledge of legal business to give us his advice on all matters that came before him. We have lost not only a man we esteemed as a friend, but a colleague of great value to this Company; and his death is a great loss to the Directors. I am extremely sorry that it has fallen to my lot for the second time to second this report in the absence of Mr. Ford, who has now gone from us for ever. Nevertheless, we must carry on the business, and I simply and formally second the resolution.

The CHAIRMAN: Does any gentleman wish to ask any questions? If not, I will put the question. He then submitted the resolution in the usual manner, and having declared it carried unanimously, said: The next resolution I have to propose is—

"*That Henry Holmes, Esq., be and he is hereby re-elected a Director of the Company.*"

Mr. WILLIAM ANDREWS: I will second that.

The motion was carried.

The CHAIRMAN: I now have to propose—

"*That Henry Weaver, Esq., be and he is hereby re-elected a Director of the Company.*"

Mr. GEORGE VON CHAUVIN seconded the motion, which was carried.

The CHAIRMAN: The next resolution relates to the re-election of the auditor, and that will come from the other side of the table.

Mr. JOHN NEWTON proposed the re-election of Mr. John George Griffiths as auditor for the ensuing year.

Mr. W. GRIFFITH seconded the resolution, which was carried.

The CHAIRMAN: That, gentlemen, concludes the business of the day, and I am obliged to you for your attendance.

Mr. JOHN NEWTON: I beg to propose a vote of thanks to the Chairman and Directors, and in doing so I wish to express my deep sympathy with them for the loss which they and the Company have sustained in the death of Mr. Ford. I happen to have been a shareholder from the commencement of his services. I well remember the time that he was appointed, and he was always an energetic and fearless advocate of the shareholders' rights. I think that an event of this kind should not pass by without some expression of sympathy on our part with his family.

Mr. HARKER seconded the motion, which was unanimously adopted.

The CHAIRMAN: We have already passed a resolution at our Board expressive of the sympathy and regret we feel at our sad loss in Mr. Ford's death, but I will take care to incorporate the feelings of the shareholders which Mr. Newton has so kindly expressed. We are much obliged to you.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

AGRICULTURAL MACHINERY COMPANY OF FRANCE (LIMITED).—Among the objects of the above named Company, which was registered on May 13th, with a capital of £80,000, in £5 shares, to acquire and carry on the business of agricultural machinery merchants, carried on by H. Thiot and Co., at Paris, Marseilles, Bordeaux, and elsewhere, is included that of carrying on the business of mechanical and electrical engineers, and also that of constructing, improving, maintaining, working, and turning to account telegraphs, telephones, electric light, heat, and power supply workers, railways, tramways, &c.

BICKLE AND CO. (LIMITED).—This Company was registered on May 13, with a capital of £50,000, divided into 4,950 ordinary and 50 founders' shares of £10 each. The objects are to acquire the business of Bickle and Co., mechanical engineers, and to carry on the business of an electrical company in all its branches, and particularly to carry on the business of electricians, electrical contractors, electrical engineers, suppliers of electricity for all purposes, and manufacturers, and hirers of and dealers in all apparatus and things required for, or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity.

LONDON AND HAMPSTEAD BATTERY COMPANY (LIMITED).—This Company was registered on May 13, 1892, with a capital of £50,000, divided into 7,000 preference and 3,000 deferred shares of £5 each. The objects are to acquire and take over as a going concern the business of electrician and otherwise carried on by Mr. Alfred W. Armstrong at Finchley-road, and in the parish of St. John's, Hampstead; to carry on in the parish of St. John's, Hampstead, and elsewhere, the business of an electric light, electric storage, or electric power supply company in all or any of its branches, and also the business of electricians, mechanical and electrical engineers, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all appliances, apparatus, and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The number of Directors is not to be less than three nor more than seven, the first being William C. Hallett, Robert J. S. Beeton, and Alfred W. Armstrong.

LONDON REAL PROPERTY AGENCY (LIMITED).—Among the objects of this Company, which was registered on May 13th, with a capital of £50,000, divided into 3,000 ordinary and 2,000 founders' shares of £10 each, is included that of constructing, maintaining, improving, developing, working and managing waterworks, gasworks, electric power, heat, and light supply works, telephone works, &c.

R. C. CUTTING, DOUGLAS AND CO. (LIMITED).—This Company was registered on May 11th, with a capital of £20,000, in £5 shares (with power to increase the same). The objects are to acquire the goodwill, plant, trade marks, and stock in trade and to carry on the business of Messrs. R. C. Cutting, Douglas and Co., lightning conductor manufacturers and electrical engineers, of Doctors' Commons, London, E.C., and to carry on any other business which may seem to the Company, directly or indirectly, to enhance the value of, or render profitable, any of the Company's property or rights.

ATLAS ELECTRIC APPLIANCES COMPANY (LIMITED).—A general meeting of the above-named Company was recently called at the offices of the liquidator, 10, Coleman-street, E.C., for the purpose of receiving the final report of the winding up, dated February 24, 1892; but there was no quorum, and therefore no business could be transacted.

GALLOWAYS (LIMITED).—The annual return of the above-named Company, made up to March 2nd, was filed on March 4th. At the time of making up, 2,108 shares had been taken up, and according to the return, the full amount has been called up on each, and the full amount £210,800 paid.

LLANELLY ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 9, 1891, was filed on March 15, 1892. The Company was registered on October 26, 1889, with a capital of £15,000, divided into 10 "A" and 14,990 "B" shares of £1 each. At the time of the making up, 7 "A" shares had been taken up, upon which nothing had been called or paid.

ST. PAUL'S PRINTING AND PUBLISHING COMPANY (LIMITED).—The statutory return of this Company, made up to May 13th, was filed on the same day. At the time of making up, 1,704 shares had been taken up, and 10s. per share had been called, resulting in the payment of £650, and leaving £202 in arrears. Among the principal shareholders are:—Robert Kaye Gray, civil engineer, of Lessness-park, Abbey Wood (500); Henry Alabaster, publisher, engineer and journalist, of 14, Therapia-road, Honor Oak (200); T. Ernest Alabaster, publisher, engineer and journalist, of 60, Gresham-road, S.W. (200); and Harry R. Kempe, engineer-in-chief G.P.O. (200).

SYNDICATE OF ELECTRICAL ENGINEERS (LIMITED).—The annual return of the above-named Company, made up to May 14, 1891, was filed on April 30, 1892. The Company was registered on December 31, 1889, with a capital of £10,000, divided in 1,900 ordinary and 100 founders' shares of £5 each. At the time of making up (May 14, 1891), 1,007 ordinary and 74 founders' shares had been taken up. £2 per share had been called on the ordinary shares, resulting in the payment of £1,903. 10s. and leaving £110. 10s. unpaid. By an agreement with Robert Hammond it was agreed that he should pay all the costs of forming and registering the Company, and in consideration thereof the 100 founders' shares were issued to him as fully paid.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—The annual return of the above-named Company, made up to April 7, 1892, was filed on April 12th. The Company was registered on February 21, 1880, with a capital of £70,000 in £100 shares. By special resolutions the shares of £100 each have been divided into 10 shares of £10 each, and the capital has been raised to £100,000 by the creation of 3,000 preference shares, bearing a fixed cumulative dividend at the rate of 7 per cent. per annum. . At the time of making up, 6,727 ordinary and 2,092 £7 per cent. preference shares had been taken up, and the full amount called, resulting in the payment of £83,330, and leaving £4,860 in arrears upon preference shares.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 15th were £709, as against £665 for the corresponding period of last year, being an increase of £44. The total receipts to date, from January 1st last, amount to £15,930, against £14,607 in the corresponding period of 1891, being an increase of £1,323.

COMPAGNIE CONTINENTALE EDISON.—The report of the Directors presented at the annual meeting recently held in Paris disclosed a favourable state of business as regards the supply of light, they having installed, up to March 31, 1892, a total of 43,942 10-c.p. lamps, as against 29,782 at the same period of 1891. The sale of the apparatus constructed at their works at Ivry had not, however, developed as much as was hoped. The accounts showed a net profit of 425,396fr., and a dividend was declared of 20fr. per share, absorbing 400,000fr.

ELMORE'S METALL-AKTIEN-GESELLSCHAFT.—This is the title of a Company just registered in Germany, and seems to indicate that the Elmore group is desirous of offering to the German public a share in the future good things which are in store for us. There is, however, nothing in the notice which appears in the *Electrotechnisches Echo* to indicate whether the above Company is affiliated with Elmore's German and Austro-Hungarian Metal Company (Limited).

REUTER'S TELEGRAM COMPANY (LIMITED).—The twenty-eighth ordinary general meeting of the shareholders of this Company will be held on Wednesday, the 1st prox., at noon precisely, at the Company's offices, No. 24, Old Jewry, London. The transfer books of the Company will be closed from the 17th until the 31st inst. inclusive.

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WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the fortnight ended May 15, 1892, amounted to £2,666, as compared with £3,155 in the corresponding period of last year, a decrease of £489.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—**The traffic receipts for the week** ended May 13, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,635.

A CORRECTION.—At the meeting of the Chelsea Electricity Supply Company, the report of which appeared in our last issue, the Chairman, in the course of his remarks, referred to 2½ years' experience, and not to 2 years' experience.

CRICKET.—EASTERN TELEGRAPH COMPANY'S HEAD OFFICE STAFF v. OFFICERS OF THE CABLE STEAMER, "JOHN PENDER."—This match was played at West Brompton on Friday, the 13th inst., and resulted in an easy win for the Head Office Staff. The "Sailors" went in first, and knocked up 37, the highest score being obtained by Chief Engineer Corns, 9. The Head Office Staff scored 108, the highest individual score being Burke (b Bonitto) 28. In their second innings the "Pender's" team fared badly, scoring only 16, of which Drake made 12. The bowling of the "Staff" was very formidable. In the first innings J. G. Macmillan captured six wickets for 11 runs, and in the second S. Wells took eight for 8. On behalf of the "Pender," Bonitto was very successful, taking six for 33 runs. In the result the "Land Lubbers" won by an innings and 55 runs. Mr. G. C. Jack captained the home team and Mr. Bonitto the "Sailors."

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 11.		Price Wednesday, May 18.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 18.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	48½	49½	48½	49½	5 6 1	Jan., Apr., July, Oct	50	48½
£2,849,510	Stock	25/0	Do. Preferred	87½	88½	88½	89½	5 18 5	,, ,,	90	88⅞
£2,849,510	Stock	5/0	Do. Deferred	11	11½	11½	12	..	,, ,,	12	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July ..	102¾	..
130,000	£10	3/0	Brazilian Submarine	10½	11	10½	11	7 5 6	Mar., June, Oct., Dec	10⅝	10½
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	101	104	4 16 2	January and July ..	102¾	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	107¾	105
$7,716,000	$100	7%	Commercial Cable Capital Stock	155	160	158	163	4 5 11	Jan., Apr., July, Oct.	159½	..
16,000	10	8/0	Cuba Submarine	10½	11½	11	12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	,, ,,	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3⅛	3⅜	3⅛	3⅜	6 18 8	April and October..	3⅛	..
6,000	5	10%	Do. Preference 10%	8½	9½	9	10	5 0 0	,, ,,	..	..
60,710	20	3/6	Direct United States	11⅜	11⅝	11½	11⅞	5 19 2	Jan., Apr., July, Oct	11⅞	11⅜
400,000	10	2/6	Eastern	14⅜	14⅝	14⅝	15	4 6 8	,, ,,	15	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 16 2	,, ,,	15⅝	15⅜
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107	110	108	111	3 12 1	May and November	109	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	108	107½
250,000	10	6/6	Eastern Extension xd and bonus	15½	15⅝	14⅞	15½	4 12 7	Jan., Apr., July, Oct.	15½	14⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	103	106	4 14 4	January and July ..	103½	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	102	105	102	105	4 15 3	,, ,,	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	100	103	101	104	3 16 11	February & August	101⅜	..
180,227	10	2/6	Globe Telegraph and Trust	10	10½	10½	10⅝	5 1 2	Jan., Apr., July, Oct.	10⅝	10
180,042	10	6%	Do. 6 per Cent. Preference	15⅛	15⅜	15⅜	15⅝	3 16 10	,, ,,	15⅞	15½
150,000	10	7/2	Great Northern xd	19	19½	18½	19½	4 9 2	Jan., April, and July	18½	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	39	41	39	41	6 1 11	May and November	40½	..
38,348	10	4/0	London Platino-Brazilian xd	6	7	6	7	6 8 7	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	5½	6½	6	7	5 14 3	April and October..	..	..
3,381	£100 Cert.	£1½	Submarine Cables Trust 6%	115	120	115	120	5 0 0	,, ,,	116½	116
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3½	3½	4½	5 11 1	January and July ..	3 1/16	3½
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	104½	..
88,321	10	1/0	West India and Panama	1⅛	1⅜	1½	1⅝	..	,, ,,	1½	1 1/16
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10 7/16	10¼
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	,, ,,	..	..
67,007	15	6/0	Western and Brazilian	9½	10	9½	10	7 10 5	,, ,,	9⅞	9 1/16
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	,, ,,	6⅝	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	3½	4	3½	4	..	,, ,,	3½	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105	108	105	108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105	108	105	108	5 11 1	,, ,,	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	115	119	115	119	5 17 8	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
224,850	14/0	3½%	Consolidated Telephone Const. & Maintenance	1/16	1/16	⅛	⅜	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	1/16	1/16	3/16	1/16	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛	4⅜	4⅜	4⅝	6 9 9	June and December	4⅜	4 7/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13	13½	13	13½	4 14 1	,, ,,	13½	13¼
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12	12½	12¼	12½	4 14 0	,, ,,	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	107	109	107	109	4 2 7	January and July ..	10⅝	108½
58,000	5	1/0	United River Plate	2	3	1½	2½	..	,, ,,	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7¼	7¾	7½	8	..	—	8	7½
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	2½	3½	2½	3½	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½	6	5½	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½	6	5½	6	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3⅜	3½	3 1/16	3 1/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5	5⅛	5 1/16	5 1/16	..	March	..	..
111,000	5	..	London Electric Supply	⅛	⅜	⅜	1	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid) xd	7½	8	7½	8	..	..	7 1/16	7⅜
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½	5½	4½	5½	—	..	..	—
18,680	£5	5/0	St. James' and Pall Mall	8½	8⅞	8½	9	—	..	9	..
7,900	£5	7%	Do. 7% Preference	7⅞	8¼	7⅞	8¼	—	..	8⅛	7 1/16
42,853	5	..	Westminster Electric Supply (fully paid)	6½	7	6½	7	..	..	6 1/16	6⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	3	3½	3	3½	..	..	3½	..
69,996	2	6%	Do. 6 per Cent. Preference	2	2½	2	2½	5 2 7	..	2½	2 1/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	5¾	5½	5¾	5 16 8	January and July ..	..	..
17,139	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅞	6⅛	5⅞	6⅛	..	—	6 1/16	5⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅛	2⅜	2⅛	2⅜	—	—	2 1/16	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	20	21	19½	20½	6 1 11	February & August	20½	19¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	102	105	4 5 9	March & September	105	..
11,334	£10	6/4	International Okonite Limited Ordinary	4	5	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼	⅜	¼	⅜	..	..	..	..
78,949	5	2/9⅝	Swan United (£3. 10s. paid) xd	3½	4½	3½	4½	9 0 9	May and November	4½	3½
36,250	12	36/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 1	March and July.....	43⅜	43
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅛	¾	⅛	¾	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½	3	2½	3	..	—	..	—
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2½	3½	2½	3½	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

Although an official imprimatur does not, as yet, in this country carry quite so much weight with the public as is the case on the Continent, electric traction has certainly won a point by the Report of the Joint Committee of Lords and Commons, which will be found elsewhere in the present issue.

With regard to the all important question of the size of tunnel, it is stated that "the evidence submitted to the Committee on the question of the diameter of the underground tubes containing the railways has been distinctly in favour of a minimum diameter of 11ft. 6in.;" from which we gather that the Committee think the tunnels ought not to be smaller, but see no particular reason why they should be bigger. They rightly point out, in paragraphs 4-8, that, with the exception of the Great Northern and City Railway, the proposed lines are in reality only *street* railways, as our Americans term them. We admit the full force of this argument, but, nevertheless, regret that the Committee did not consider the future. Steam railways were so utterly unlike anything that had preceded them that want of prescience was excusable, and the laying down of lines on half-a-dozen different gauges a venial error. But this does not hold good for 1892.

As to the increase in first cost which the adoption of 16ft. tunnels would entail, Sir Douglas Fox's estimate for them is £650,000 per mile, a figure which compares favourably with the million a mile of the Inner Circle. Again, as Mr. Wolfe Barry pointed out, a railway able to carry all the traffic of the country is double the value of one which can only carry strictly urban traffic. However, if the promoters of these schemes do not see matters in this light, and if it is really a choice between small tubes or none at all, by all means let the tubes be small. The example of the Great Northern Railway will, in all probability, soon be followed, and the lines for which we are contending will be built by the existing railway companies instead of by the present pioneers; that will be the only difference.

While the usual Ministerial State dinners were being given in celebration of Her Majesty's birthday on Wednesday last, a less formal and probably more agreeable evening was spent at the Crystal Palace by members of the Whitehall Club and their guests. Special experiments were provided in the afternoon at the side shows. Messrs. Swinburne & Co. ran a current under a pressure of about 100,000 volts through a large roofing slate from corner to corner; the current was then transformed down to a pressure of about 80 volts, and was used to run an arc lamp and a self-starting motor. Messrs. Siemens Bros. showed the glowing of a long vacuum tube without wires, and one or two other Tesla experiments. During the dinner, between 70 and 80 cutlets and about 40 pancakes were cooked on electrically heated frying-pans, and coffee was also made.

It is remarkable that, until these demonstrations of the domestic application of electric currents, little or nothing has been done in this direction since the Crystal Palace Electrical Exhibition of 1882. Lane Fox then showed his egg-boilers and coffee-pots, and the cooking is being done at the present Exhibition exactly on his system with enamelled wires. We recently gave some calculations of the expenditure of energy required, and took the case of boiling a pint of water. It has, however, been pointed out to us that to boil water is one of the stiffest tasks that can be set. This is no doubt the case, since nothing has a higher specific heat than water.

It ought to be better known that the cooking pans and flat-irons which have attracted so much attention can be used on an ordinary lamp circuit. An iron takes about four amperes when cold, and the current soon drops when the metal warms up. A wire of No. 18 gauge is often used for single lamps, and most wiring rules prohibit smaller sizes. We think that for mechanical reasons No. 18 is too small, and a larger size, or 3/22, ought to be employed. The sectional area of No. 18 S.W.G. is practically the same as that of 3/22, and the diameter is 0·048in. Mr. Kennelly found that it took 5 amperes to raise a wire of 0·043in. diameter insulated and enclosed in ordinary wooden casing, 18° Fahr.; it is not, therefore, necessary to alter the wiring of a house to enable these useful applications to be employed.

It was satisfactory to hear from Mr. A. R. Bennett on the occasion of the press gathering on Wednesday last, at 110, Cannon-street, that the New Telephone Company is really about to proceed from promise to performance. One month's canvass has, it was stated, resulted in more than 2,500 adherents, and London is shortly to enjoy all the blessings of the Mann system of switching, twin underground wires, double-pole Bell receivers, and Johnson transmitters. Whether the

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New Company's spirited attack upon the National Company's metropolitan stronghold will meet with the financial reward it deserves, is a matter which the advisers of the venture have doubtless thoroughly weighed before embarking in the enterprise; for our own part we cannot confess to very sanguine anticipations on this point. This much may be predicted. The manifold inconveniences of two competing telephone companies will soon cause the public to make up its mind to support one or the other in a thoroughly effective manner, and when that determination is arrived at, either the New or the National Company will have to promptly make peace with its antagonist on the best terms it can. It will be a Six Weeks' rather than a Six Years' war.

As far as mere electrical equipment is concerned, the New Telephone Company will make a good start. Complete metallic circuits and underground wires are in themselves a sufficient recommendation; and, whatever may be urged against it, there can be but little doubt that the Mann system, in doing away with two distinct operations on the part of the operator, should result in increased celerity in connecting subscribers. The Johnson transmitter again is an improvement upon the Blake, which frequently gets out of adjustment when most wanted. The Johnson transmitter, we may mention, is much the same as the Binswanger-Coates microphone described in our issue of September 4, 1891. Finally, if there be a better receiver than the plain Bell, it is probably the double-pole Bell.

At an inquest held on the deaths resulting from a fire in the Haymarket, a consulting engineer made, what is called in Police courts, "a rambling statement," full of surmises and possibilities, but devoid of facts or anything that could be called evidence. He discovered that some wires were run under plaster near some gas pipes, and understood that the building was insured in the Phœnix office; but he was sure that their inspector would not have tolerated the position of them if he had known their proximity to the gas pipes. We understand that only a very small portion of the insurance was effected quite recently with the Phœnix office, and that it had not been inspected. The public are now well aware that there is no danger whatever if the wiring is properly done, and that the inspection by the officers of the Fire Insurance Companies and the conditions of the Supply Companies are quite sufficient to ensure perfect safety. The fact that no fire has ever occurred from electric lighting where the wiring has been carried out with what is to-day considered ordinary care, is in itself a proof of the absence of danger. A few fires have occurred, and all of these have been distinctly traced to ignorant work. Confidence in electric lighting is now sufficiently well established to be unshaken by such vague guesses as were presented at this inquest.

The Coroner gave it as his opinion that "danger of fire from an installation of the electric light appeared to be greater than in the case of an escape of gas;" but displayed his entire ignorance of the matter by saying that "it was to be regretted that there were no set rules for the performance of the work." This, when Codex Heaphæ has reached its nineteenth edition, to say nothing of the joint Fire Risk Rules of the twenty-five leading companies, the regulations of eight supply companies, and those of the Institution of Electrical Engineers, besides the specifications both of contractors and of consulting engineers!

Electricity seems destined to afford lawyers of all lands an opportunity of showing their professional skill at splitting hairs. In America several legal questions have cropped up. Is electricity dutiable? Can it be stolen? In France it was a moot point until a short time ago whether an electricity supply Company was a Société Civile or a Société Commerciale, a matter of no little importance to investors, who in the latter case would only be liable for the amount of their shares. A Société Commerciale, it appears, is one which has for its principal object "the accomplishment of acts of commerce," such as buying raw material and reselling it at a profit, manufactured, or in its natural state. The Edison Company of Saint Etienne, summoned before the Tribunal of Commerce of that town by one of its customers, declined to submit to the jurisdiction of the Court on the ground that the supply of electricity from a central station did not constitute a commercial act, "the company only sold a product which it gathered from nature, and which was a *res nullius*." The Tribunal of Commerce, nevertheless, declared itself competent to try the case, and on appeal its decision was upheld; so that in France, at any rate, electricity when supplied from a central station must be deemed a manufactured article. Across the Atlantic, where the manufacturing interest is dealt with very tenderly by the tax gatherer, a similar decision would add appreciably to the profits of central stations.

Crystal Palace Electrical Exhibition.—It has been decided to close this Exhibition on Saturday, July 2nd.

Damage by Lightning.—An assistant at the Cape Observatory was struck by lightning while attending to the rain gauge, and severely injured.

The Frankfort Exhibition.—The publication of the Official Report on the Exhibition and of the Official Report of the Jury is postponed until the end of the summer.

Birthday Honours.—Among the gentlemen created K.C.B. on the occasion of Her Majesty's birthday was Mr. Courtenay Boyle, Assistant Secretary to the Board of Trade.

Charlottenburg.—According to the *Charlottenburg Zeitung* Messrs. Siemens and Halske have obtained a concession for an electric tramway between Charlottenburg and Berlin.

Panama.—According to *El Telegrafo Español*, an electric tramway is to be constructed in Panama. Several central stations are to supply current for the 30 H.P. motors to be used. The latter, it is said, are being built by Messrs. Siemens Brothers.

Copper.—Negotiations between the European and American Companies progress favourably, says *The Statist*. The negotiations contemplate a restriction of the output, but not such as would greatly enhance the value of copper, or in any way inconvenience consumers. A very friendly spirit is evinced by all parties.

The Electrical Trade Union.—On Thursday last week a meeting of men engaged in the electrical trades in Leeds was held. It was stated that the Leeds branch has only been established about twelve months, and numbers 61 out of a constituency of

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about 100, and within three months of the formation of the union the wages of the men were raised 5s. per week all round.

Glasgow.—Last week the Deputy Town Clerk was summoned to the Central Police Court on a charge of allowing black smoke to issue from the furnaces at the electric lighting station in John-street. In imposing a fine of 40s., the magistrate remarked that the Corporation, who were endeavouring to have the penalties for smoke nuisances increased, should be the first to set an example to others.

Electrical Bills in Parliament.—The following Bills were read a second time in the House of Commons on Monday:—Liverpool Overhead Railway Bill, Baker-street and Waterloo Railway Bill, Great Northern and City Railway Bill, Hampstead, St. Pancras, and Charing Cross Railway Bill, and Waterloo and City Railway Bill. On Wednesday the Central London Railway Bill and City and South London Railway Bill were read a second time.

Electric Lighting of the Theatre and Hall in Vienna.—For the electric lighting of the theatre and hall in Vienna, which was started on 7th inst., 1,200 H.P. are being used. The work has been carried out by Messrs. Siemens and Halske. The dynamos are driven by six 200 H.P. engines built by the Maschinenfabrik Waniek, and steam is supplied by tubular boilers by Messrs. Simonis and Lanz, having a total heating surface of 13,500 square feet.

The Metropolitan Electric Railway Schemes.—The Baker-street and Waterloo; Great Northern and City; Hampstead, St. Pancras and Charing Cross; Waterloo and City; Central London; and City and South London Railway Bills, have been referred to a Select Committee of the House of Commons, consisting of Sir John Kennaway (Chairman), Mr. Esslemont, Mr. T. W. Sidebotham, and Mr. E. Holden. The first meeting of the Committee will be held on Tuesday next, at 11:30.

The Faure Patent in Germany.—We are informed that the Supreme Court of Appeal at Leipsig has just delivered a judgment confirming the decision of the Patent Office at Berlin, and establishing the validity of the Faure Patent. Several of the secondary battery manufacturers in Germany had entered process in the Patent Office, seeking to have the Faure Patent declared invalid on the ground that its main features had been anticipated. This contention has now been finally disposed of in favour of the Faure Patent.

Chicago Exhibition.—To enable visitors to the Machinery Hall to pass from one end of the building to the other at an elevation, and thus gain a birdseye view of the exhibits, three large electric travelling cranes will be constructed, each with a lifting and carrying capacity of 20 tons. Previous to the opening of the Exhibition these cranes will be used for the moving of heavy exhibits; afterwards they will be covered with broad platforms capable of carrying several hundred people at each trip.

The Best Frequency for Alternating Currents.—Having regard to all the circumstances of the case, says *Industries*, we believe the American frequency of 130 is about the right one, and that low limits, such as 40 or 60, are a mistake. Recently we have seen 20 periods per second proposed. This would be ruinous both to the pocket and to the eyesight. Helmholtz found that the eye could distinguish 25 periods per second. This low frequency would probably be unworkable in the dynamos, motors, and especially in the transformers.

The Electric Arc.—In the course of some insurance litigation before an American Court relative to liabilities of insurance companies at the destruction of an electric light station, one of the experts, says *Engineering*, took the position that an electric arc was not a flame, because it was not in any way dependent upon the air or other chemical support, and could be maintained *in vacuo*, and therefore the damage done by the arc did not come within the liability of the underwriters, although they accepted liability for the measure of damage caused by fire resulting from the arc, yet the portion of damage caused by melting of the apparatus by the arc was not included in that damage.

Manchester.—Mr. S. J. Smith, one of the Inspectors of the Local Government Board, held an inquiry last week into the application of the Town Council to borrow the sum of £150,000 for purposes of electric lighting. Sir John Harwood, who was called upon to give evidence, said the Corporation had had the question of electric lighting under consideration for the last ten years at least. He thought that the money now applied for was little enough, and that it would have been better to borrow £200,000. The contracts which had been already let and others which would be let shortly amounted to £78,000. Dr. John Hopkinson, who was next called, said that the best system under the circumstances was the five-wire system. The inquiry then closed.

Train Lighting.—The Brush Electrical Engineering Corporation showed a train-lighting dynamo in operation at their Lambeth Works on Friday last. A Brush machine was used, and was arranged for driving from the axle of a guard's van. The commutator was filled up flush with mica, to allow butt brushes of wire gauze to be used. A centrifugal governor was connected to the brushes by a system of levers, which we were unable to examine, as they were enclosed in a box; the effect was to rock the brushes over, to keep the volts constant. Relays, automatic switches, and resistance coils are used for exciting the fields, charging accumulators, and for running the lamps direct, on a system worked out mainly by Mr. Houghton, of the Brighton and South Coast Railway.

Electric Traction on the Baltimore and Ohio Railroad.—The Thomson-Houston Company has offered, and the Baltimore and Ohio Company has accepted the offer to run the trains in the Belt tunnel under Baltimore by means of electricity. Eighty-ton locomotives, with armatures direct on the axle, will be employed. The Thomson-Houston Company guarantees that its plant and system shall be successfully installed and operated before it is paid for. The Thomson-Houston Company proposes to guarantee the transportation of goods trains of a maximum weight of 1,300 tons at the rate of fifteen miles up the grade in the tunnel, and passenger trains of one-half that weight at thirty miles an hour. The power of each motor is to be guaranteed as equal to a draw-bar pull of 32,000lbs. There will be four engines in the power house of 700 H.P. each. The plant is to come into operation in December next.

The Albert Medal of the Society of Arts.—The Albert Medal of the Society of Arts for the present year has been awarded to Mr. Thomas Alva Edison, in consideration of the distinguished services rendered by him to the progress of electric lighting, telegraphy, and the telephone. This medal was instituted in 1862 as a memorial of the Prince Consort, for 18 years the President of the Society, and is awarded annually for distinguished merit in promoting arts, manufactures, or commerce. It was first awarded in 1864 to Sir Rowland Hill, and amongst the distinguished men of science who have since received it have been Faraday, Whitworth, Liebig, Lesseps, Bessemer, Siemens, Armstrong, Thomson, Joule, Hofmann, and Helmholtz. In 1887 it was presented to Her Majesty on the occasion of her jubilee. This is the second occasion on which it has been awarded to an American. In 1884 it was given to Captain Eads in recognition principally of his great engineering works at the mouth of the Mississippi.

The Chief Electrician to the Post Office.—On Friday evening last, Mr. Labouchere asked the Postmaster-General whether he was aware that Mr. W. H. Preece was in the habit of taking private practice in electrical work; and whether, in view of the fact that he was a Civil servant in receipt of an annual salary, that was in accordance with the rules of the Civil Service. Sir J. Fergusson said that the case of Mr. Preece was exceptional. Before he entered Her Majesty's service, 22 years ago, he held certain paid employments besides his appointment as engineer of the Electric Telegraph Company. Those employments he relinquished as being incompatible with his appointment at the Post Office; but, with the knowledge of the department, he had continued to advise on great electrical questions outside of his regular duty. His action in this respect had been quite public, and his reports had been published. His official work was by no means confined to office hours. It was performed unsparingly early and late. The case was altogether exceptional, and could not form a precedent.

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The Azores Cable.—The Lisbon correspondent of *The Times*, under date May 25, writes:—"A single tender only—namely, the one from the French company—was made this afternoon for the laying of the cable from Lisbon to the Azores. This Company offers to accept all the conditions laid down, together with some pecuniary advantages, to lay cables from the Azores to the Antilles and South America, or from the Azores to Central or North America within three years; and to lay a cable from Fayal to Flores by April, 1893. It has also presented an official letter from the French Government according it the exclusive right during five years to lay cables between France, Portugal, and the French colonies, and another document by which the Government of Hayti accords it the exclusive right for 30 years to land cables on Haytian territory. In reference to their proceedings in these negotiations, I understand that the Portuguese Government yesterday received an expostulation from the British Government. But, notwithstanding the diplomatic intervention of their Government, I understand that the British Company (the Telegraph Construction and Maintenance Company) are disposed to withdraw their protest, and lay the cable to the Azores this summer upon receiving fair treatment from the Portuguese Government."

Lichtenfeld's Electric Railway Signals.—A system of electric signals, invented by Mr. Sigismund Lichtenfeld, is being noticed at some length by the daily press. We recently had an opportunity of examining a model representing a signal cabin and part of a double-track railway. The inventor proposes his system as an addition to those at present in use, and claims that by its means the signal-man would be made aware of the position of a train at short intervals, and could signal from his box to the driver on the locomotive direct. The system is not affected by foggy weather, and the ordinary fog-signals would not be needed. We may say at once that it is a system of signalling by means of electric bells or single needle instruments and indicators. Special insulated rails are laid parallel to the ordinary rails. Underneath the locomotive a suitable contact is fixed. As the locomotive passes over the part of the line where the insulated rails are fixed a battery circuit is completed through the contacts and the ordinary rails as a return circuit, and bells should ring in the signal-box and on the locomotive, and indicators should work. We use the word "should" because such electric connections are so liable to get out of order. We fear that in its present form the invention is inapplicable to most lines, owing to its expense and unreliability.

The Electrical Trade Section.—The annual meeting of the Electrical Trade Section will be held at Botolph House, Eastcheap, at 2.30 p.m. to-day, to consider the appended agenda. A full attendance is particularly requested. *Agenda.*—1. Chairman's report as to the work of the Section since its last annual meeting. 2. Election of chairman and deputy chairman for the ensuing year. 3. To consider the desirability or otherwise of the Section following the precedent of other Sections of the Chamber, in convening the whole of the membership of the Section to all future meetings, appointing special committees to deal with special subjects. 4. The attitude of the electrical trade towards the Chicago Exhibition. 5. Telephone question. 6. The attitude of the Section towards the Parliamentary Committee, who are to consider the whole question of electric railways in London. 7. The action taken by the Chamber in reference to the question of Overhead Wires, and to consider the reply from the President of the Board of Trade. 8. Bye-Laws of the County Council in reference to Overhead Wires. 9. Electrical communication on the coasts. 10. Commercial Education.—To consider whether the Section would be prepared to support the commercial education scheme of the Chamber by subscribing annually for a prize or prizes to be awarded in the name of the Section. 11. Co-operation of the Section with the New Mining Section of the Chamber. 12. Proposed addresses. 13. Other matters.

The National Telephone Company and its Sheffield Subscribers.—An interview took place last week at the offices of the Chamber of Commerce between the Committee appointed by the recent meeting of users of the National Company's telephone system and a deputation of the Directors of the Company. Mr. Gaine stated that the tariff which had caused so much dissatisfaction in Sheffield was based upon the working of the Company's system in Lancashire. He then submitted the new tariff. The new scale of charges was an annual payment of £8 for the use of a wire within a mile and a half radius of the parish church or of any exchange within the free radius; an annual payment of £10 for a two-mile radius; and a payment of £2. 10s. per annum for every half-mile beyond that radius. The charge for private houses would be £7 per annum if they were within the two-mile limit. Mr. Gaine stated that the Company was prepared to enter into a contract with subscribers for any length of time at the proposed new rates. After a lengthy discussion the deputation withdrew, and the Committee proceeded to discuss the new rates. No decision, however, was arrived at. The Committee also had an interview with Mr. A. R. Bennett, who stated the terms on which the New Telephone Company were prepared to come to Sheffield. On Tuesday the Committee again met, and decided that the proposed long-distance charges were excessive. A Sub-Committee was appointed to draw up a report on the negotiations to be presented to the meeting of the subscribers, called for Monday next. It is understood that the National Company will modify the long-distance charges.

The Telephone in Canada.—The following statistics with regard to telephonic activity in the Dominion are culled from the *Canadian Electrical News*, of Toronto. By comparing these statistics with those of other countries it will be seen, says our Toronto contemporary, that we occupy an enviable position, both as regards the extent and efficiency of our telephone service, and the moderateness of the price at which it is furnished. The telephone rentals charged in some of the principal cities of the United States are as follows:—

New York	£48
Boston	40
Chicago	25
Philadelphia	20
St. Louis	20
Cincinnati	20
Buffalo	10 and 2½d. per call.
Kansas City	14. 10s.

In Canada the average rate is a little over £6. At Montreal the annual rental amounts to £10, and at Toronto it is £9. As evidence of the popularity of the telephone in Canada, it may be mentioned that 540 telephones are in use per 100,000 inhabitants, as against 350 for the United States and 167 for the United Kingdom. Again, in Montreal, there are 25 instruments per 1,000 inhabitants, against 17 in Berlin, 5 in Vienna, 4·2 in Paris, and 1·5 in London. The growth of the Canadian telephone system is shown by the following figures:—

	1880.	1892.
Montreal	312	5,872
Toronto	353	3,965
Hamilton	181	1,160
Quebec	124	1,011
Halifax	87	955
Ottawa	230	942
London	104	805

When the telephone was first introduced, says our contemporary, the public was as anxious to grant facilities as they are to-day prompt to refuse them. At that time it seemed as though every city took pride in having as many poles as possible, and in one notable instance the city gave permission to erect poles in its streets provided they were placed in every street, or, in the words of the contract, "the city shall be fully poled." After alluding to the expensive nature of the telephonic business owing to the continual improvement of apparatus, and the more careful construction rendered necessary by the advent of the "trolley," another very serious source of loss to the companies, remarks the *Electrical News*, is the frequency of sleet storms, which have in many instances totally wrecked their plant and rendered entirely new construction imperative, without any increase of revenue. The storm of March 11, 1892, in Ottawa, caused a loss to the companies, in poles and overhead wires, of probably between £4,000 and £6,000.

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ELECTROMAGNETIC THEORY.—XXIX.

BY OLIVER HEAVISIDE.

(*Continued from page 31.*)

§ 135. Deferring temporarily a vectorial proof of the last formula (229), which is the only unproved formula in the connections of the series of circuital vectors, it will now be convenient to bring together the connections of the divergent vectors and associated quantities. We saw the advantage of the systematic arrangement of the connected circuital vectors to be like producing a harmonious chord out of apparently disconnected tones. The advantage is much greater in the divergent series, on account of the less uniform relations involved and the greater need of a system to bring them under rapid mental control. In the circuital series, four kinds of operation were involved; but in the divergent series there are six. The chord will be found to be perfect, though of greater complexity.

Thus, let

$$\mathbf{A}_2, \quad \mathrm{B}_2, \quad \mathbf{C}_2, \quad \mathrm{D}_2, \quad \mathbf{E}_2, \ldots .$$

be a series of vectors and scalars connected as follows:—Start with $\mathbf{A}_2$, which is to be any divergent vector; that is, having no curl. Let B_2 be its divergence; $\mathbf{C}_2$ the slope of B_2; D_2 the divergence of $\mathbf{C}_2$; $\mathbf{E}_2$ the slope of D_2, &c. Then $\mathbf{A}_2$, $\mathbf{C}_2$, $\mathbf{E}_2$, . . . are all divergent vectors. But they are separated from one another by two steps instead of one, as was the case in the circuital series last treated. The intermediate quantities are scalars. Instead, also, of the single operation of curl which suffices, in the circuital series, to carry us from any vector to the following one, we now have two distinct operations; viz., that of slope, when we pass from a scalar to the next vector, as in

$$\mathbf{C}_2 = -\nabla \mathrm{B}_2; \quad . \quad . \quad . \quad . \quad . \quad . \quad (230)$$

and that of divergence, when we pass from a vector to the next scalar, as in

$$\mathrm{D}_2 = \mathrm{div}\, \mathbf{C}_2. \quad . \quad . \quad . \quad . \quad . \quad (231)$$

But if we wish to go down two steps at once, we can do so by means of the Laplacean operator, whether the operand be a scalar, as in

$$-\nabla^2 \mathrm{B}_2 = \mathrm{D}_2, \quad . \quad . \quad . \quad . \quad . \quad (232)$$

or else a vector, as in

$$-\nabla^2 \mathbf{C}_2 = \mathbf{E}_2. \quad . \quad . \quad . \quad . \quad . \quad (233)$$

In this respect, then, we have the same property as in the circuital series.

We have also identity of operation in going up two steps at once, whether from a scalar to the next higher scalar, as in

$$\mathrm{B}_2 = \mathrm{pot}\, \mathrm{D}_2, \quad . \quad . \quad . \quad . \quad . \quad (234)$$

or from a vector to the next higher vector, as in

$$\mathbf{C}_2 = \mathrm{pot}\, \mathbf{E}_2; \quad . \quad . \quad . \quad . \quad . \quad (235)$$

any member of the series being the potential of the second after, as in the circuital series.

Next, to go up one step only, we may utilise the preceding in two ways. First go up two steps and then down one, as in

$$\mathrm{B}_2 = \mathrm{div}\, \mathbf{A}_2 = \mathrm{div}\, \mathrm{pot}\, \mathbf{C}_2, \quad . \quad . \quad . \quad (236)$$

where we pass from the vector $\mathbf{C}_2$ to the scalar B_2 by pot first (up two steps), and then by div (down one step); and also as in

$$\mathbf{C}_2 = -\nabla \mathrm{B}_2 = -\nabla\, \mathrm{pot}\, \mathrm{D}_2, \quad . \quad . \quad . \quad (237)$$

where we pass from the scalar D_2 to the vector $\mathbf{C}_2$ by pot first (up two steps), and then by $-\nabla$ (down one).

Or, secondly, we may first go down one step and then up two, as in

$$\mathrm{B}_2 = \mathrm{pot}\, \mathrm{D}_2 = \mathrm{pot}\, \mathrm{div}\, \mathbf{C}_2, \quad . \quad . \quad . \quad (238)$$

when rising from the vector $\mathbf{C}_2$ to the scalar B_2; or as in

$$\mathbf{C}_2 = \mathrm{pot}\, \mathbf{E}_2 = -\mathrm{pot}\, \nabla \mathrm{D}_2, \quad . \quad . \quad . \quad (239)$$

when rising from the scalar D_2 to the vector $\mathbf{C}_2$.

Finally, if we wish to rise up one step at once, without using the double step either up or down, we can do it by means of

$$\mathbf{C}_2 = (\mathrm{div})^{-1}\, \mathrm{D}_2 = \Sigma \mathbf{r}_1 \mathrm{D}_2 / 4\pi r^2, \quad . \quad (240)$$

when we rise from a scalar D_2 to a vector $\mathbf{C}_2$, which is, in fact, the fundamental formula of the inverse square law upon which our potential investigations are based. But in rising from a vector $\mathbf{C}_2$ to the scalar B_2 just above it in the series, we require to use a different process, namely,

$$\mathrm{B}_2 = (-\nabla)^{-1} \mathbf{C}_2 = -\Sigma \mathbf{r}_1 \mathbf{C}_2 / 4\pi r^2. \quad . \quad . \quad (241)$$

In these formulæ (240), (241), $\mathbf{r}_1$ is a unit vector from the element in the summation towards the place of the resultant; that is, from D_2 to $\mathbf{C}_2$ in (240), and from $\mathbf{C}_2$ to B_2 in (241).

We now have a complete scheme for the divergent vectors as we had before for the circuital series. On comparing them we see that they are alike in the double steps, either up or down, but differ in the single steps. There is but one kind of step up and but one kind down in the circuital series, whereas there are two kinds up and two kinds down in the divergent series. The down step in the circuital series is always done by curl; the up step, shown in (229), may be denoted by $(\mathrm{curl})^{-1}$. In the divergent series the down steps are done by $-\nabla$ and by div; their inverses may be denoted by $(-\nabla)^{-1}$ and $(\mathrm{div})^{-1}$. It is now the nature of these inverse operations (229), (240), and (241) that remains to be elucidated vectorially. The first is the Ampèrian formula rationalized, whereby we rise from electric current to its magnetic force; by the second we rise from (for instance) electrostatic force to the electrostatic potential; or, with a slight change (of sign), from intensity of magnetisation to magnetic potential; in the third we rise from (for instance), electrification to electrostatic displacement.

§ 136. Let p and q be scalar functions, and consider the space-variation of their product. We have

$$\nabla(pq) = p\nabla q + q\nabla p, \quad . \quad . \quad . \quad . \quad (242)$$

a formula not previously used, but which is seen to be true by observing that it is true for each of the three components of ∇. Now integrate through any region. We know that

$$\Sigma \mathbf{N} pq = \Sigma \nabla(pq), \quad . \quad . \quad . \quad . \quad . \quad (243)$$

if $\mathbf{N}$ is the unit normal outwards from the boundary of the region, so that the left member is a surface-summation, whilst the right member is a volume-summation throughout the region bounded by the surface. Equation (243) is, in fact, a case of (157), with pq substituted for p. If, then, the surface-summation vanishes, we shall have a simultaneous evanescence of the right member of (243), and therefore, by (242),

$$\Sigma p \nabla q = -\Sigma q \nabla p. \quad . \quad . \quad . \quad . \quad . \quad (244)$$

All the work done by a vector analyst is exhibited in (244) itself, viz., the transfer of the symbol ∇ from one operand to the other, with change of sign, converts the integral of $p\nabla q$ into that of $-q\nabla p$. The previous remarks contain the justification of the process.

Now $-\nabla q$ is a polar or divergent vector, so may be any one of our divergent series, say $\mathbf{C}_2$, when q itself becomes B_2. Then

$$\Sigma p \mathbf{C}_2 = \Sigma \mathrm{B}_2 \nabla p. \quad . \quad . \quad . \quad . \quad . \quad (245)$$

Lastly, let p have the special value $1/4\pi r$; then (245) is the same as

$$\mathrm{pot}\, \mathbf{C}_2 = \mathbf{A}_2 = \Sigma \mathrm{B}_2 \nabla p, \quad . \quad . \quad . \quad . \quad (246)$$

which exhibits the divergent vector $\mathbf{A}_2$ in terms of its divergence B_2. It is the same as (240), since $\nabla p = \mathbf{r}_1 / 4\pi r^2$, if $\mathbf{r}_1$ is the unit vector from B_2 to $\mathbf{A}_2$.

§ 137. Next, substitute for q in pq a vector, say $\mathbf{g}$. The new quantity $p\mathbf{g}$ has, being a vector, both curl and divergence, in general. Considering the latter first, we have

$$\mathrm{div}\, p\mathbf{g} = p\, \mathrm{div}\, \mathbf{g} + \mathbf{g}\nabla p, \quad . \quad . \quad . \quad (247)$$

which is an example of (160). Integrating throughout any volume, we have

$$\Sigma \mathbf{N} p\mathbf{g} = \Sigma\, \mathrm{div}\, p\mathbf{g}, \quad . \quad . \quad . \quad . \quad (248)$$

as in (159), where $\mathbf{N}$ is as before. So, if the surface-integral vanishes, we obtain, by (247),

$$\Sigma p\, \mathrm{div}\, \mathbf{g} = -\Sigma \mathbf{g} \nabla p, \quad . \quad . \quad . \quad . \quad (249)$$

and, in this transformation, all the vector-analyst has to do is

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to shift the operator ∇ from one operand to the other, and change the sign.

The vector $\mathbf{g}$ here has no restriction imposed upon it. It may therefore be of the general type $\mathbf{C} = \mathbf{C}_1 + \mathbf{C}_2$, giving

$$\Sigma p\mathrm{D}_2 = -\Sigma \mathbf{C}\nabla p = -\Sigma \mathbf{C}_2\nabla p \quad . \quad . \quad . \quad (250)$$

Here the portion $\Sigma \mathbf{C}_1\nabla p$ vanishes because $\mathbf{C}_1$ is circuital and ∇p is polar, which is one of the important theorems in analysis that become visibly true by following the tubes of the circuital flux in performing the summation, when the summation is seen to vanish separately for every tube. (*See* § 87).

If in (250) we give p the special value $1/4\pi r$, viz., the potential due to a unit source at distance r, we obtain

$$\text{pot } \mathrm{D}_2 = \mathrm{B}_2 = -\Sigma \mathbf{C}\nabla p = -\Sigma \mathbf{C}_2\nabla p, \quad . \quad . \quad (251)$$

showing how to pass up one step in the divergent series from a vector to the preceding scalar. It is the same as (241), remembering the value of ∇p.

§ **138.** Thirdly, we have the curl of $p\mathbf{g}$ to consider. Here, by (188),

$$\text{curl } p\mathbf{g} = p \text{ curl } \mathbf{g} - \mathrm{V}\mathbf{g}\nabla p, \quad . \quad . \quad . \quad (252)$$

Integrating throughout any region, we obtain

$$\Sigma \mathrm{V}\mathbf{N}p\mathbf{g} = \Sigma \text{ curl } p\mathbf{g}, \quad . \quad . \quad . \quad . \quad (253)$$

which is a case of (162), with $p\,\mathbf{g}$ put for $\mathbf{H}$. So, if the surface-summation vanishes, we obtain, by (252),

$$\Sigma p \text{ curl } \mathbf{g} = \Sigma \mathrm{V}\mathbf{g}\nabla p, \quad . \quad . \quad . \quad . \quad (254)$$

when the symbol $\mathrm{V}\nabla$ is moved from $\mathbf{g}$ to p, with a change of sign, as before. In this, take $p = 1/4\pi r$; then, since there is no restriction upon $\mathbf{g}$, we get, taking $\mathbf{g} = \mathbf{C}$,

$$\text{pot } \mathbf{D}_1 = \mathbf{B}_1 = \Sigma \mathrm{V}\mathbf{C}\nabla p = \Sigma \mathrm{V}\mathbf{C}_1\nabla p, \quad . \quad . \quad (255)$$

which is the companion to (251), showing how to pass up one step in the circuital series, from $\mathbf{C}_1$ to $\mathbf{B}_1$. This is equivalent to (229). The divergent part of $\mathbf{C}$ contributes nothing. That is to say, for example, the magnetic force due to a completely divergent distribution of electric current, according to Ampère's formula for the magnetic force of a current *element*, is zero. We might, indeed, argue from this, that there could not be such a kind of electric current; that is to say, that the current must be circuital, since the mathematical machinery itself, constructed on old ideas, automatically rejects the want of circuitality, and refuses to admit the purely divergent part as contributory to magnetic force. This is a perfectly valid argument, provided the test of the existence of electric current be the existence of magnetic force, which is tantamount to what Maxwell insisted upon, in another form.

For instance, if we calculate by (255) the magnetic force due to a supposititious current element at a point, simply by removing the sign of summation, we obtain the magnetic force of a rational current element, a system of circuital current resembling the induction due to a magnetised particle. (*See* § 62.)

§ **139.** Returning to the three single up-step formulæ, it will be observed that in every case we base the proof upon the vanishing of a surface-integral, viz., $\Sigma \mathbf{N}pq$, or $\Sigma \mathbf{N}p\mathbf{g}$, or $\Sigma \mathrm{V}\mathbf{N}p\mathbf{g}$. Now it is obvious that these are true if the surface be taken wholly outside the region occupied by the quantity q or $\mathbf{g}$. The value pq or $p\mathbf{g}$ is made zero all over the surface of summation. This is what occurs in the applications made. In (246) the space-summation has to include all the B_2, which represents q; it is sufficient, therefore, for the surface to completely enclose all B_2. Again, in (255), the enclosure by the surface of all $\mathbf{C}$, which represents $\mathbf{g}$, will ensure the vanishing of the surface-integral; and in (251) the same. Now, it is usual to imagine the surface to be at infinity, so that the space-summations extend over all space. This is also most convenient, in general. But caution is sometimes necessary when the quantity to be summed extends to infinity. The surface-summation then may, or may not, vanish, according to circumstances. Even if the quantity summed becomes infinitely small at infinity, the summation may still not vanish To illustrate this, it is sufficient to mention the case of a single point-source. The surface-integral of the flux it produces is finite always, being the measure of the strength of the source. At infinity the flux may be infinitely attenuated, but the surface is simultaneously infinitely magnified. But in the application of the above processes to practical cases in electromagnetism it is usually quite easy to see that the integral over the surface at infinity vanishes, owing either to the actual absence of anything to be summed, or else, when there is an infinitely attenuated quantity to be summed, of its being, per unit area, of lower dimensions than $1/r^2$. The quantity p itself attenuates to nothing, as well as q or $\mathbf{g}$, if they are existent at all at infinity.

The three up-step formulæ may, by inspection, be transformed so as to involve entirely different operations. Thus, in (241), put p for $1/4\pi r$. Then we have

$$\mathrm{B}_2 = -\text{pot } (\mathbf{C}_2/\mathbf{r}). \quad . \quad . \quad . \quad . \quad (256)$$

Do the same in (240), and we obtain

$$\mathbf{C}_2 = \text{pot } (\mathrm{D}_2/\mathbf{r}). \quad . \quad . \quad . \quad . \quad . \quad (257)$$

Finally, (229) gives

$$\mathbf{C}_1 = \text{pot } (\mathrm{V}\mathbf{D}_1/\mathbf{r}). \quad . \quad . \quad . \quad . \quad (258)$$

We may sometimes utilise these formulæ for purposes of calculation, should the integrations to be performed be amenable to practical treatment. But there is a caution to be mentioned. The quantities whose potentials are calculated by the last three formulæ are not functions of position, which are definitely distributed in space, and are independent of the position of the point where the potential is reckoned, but are definite only when this point is fixed. As you pass to another point, the potential, there is that of a different distribution from that belonging to the first point. These quantities, $\mathbf{C}_2/\mathbf{r}$, &c., are therefore not subject to the various properties of the circuital and divergent vectors already considered. For example, $\mathbf{C}_2$ is purely divergent, but $\mathrm{D}_2/\mathbf{r}$ has curl; or, $\mathbf{C}_1$ is circuital, whilst $\mathrm{V}\mathbf{D}_1/\mathbf{r}$ has divergence, and so on.

§ **140.** The transformations (244), (249), (254), or the more general ones containing the omitted surface-summations, expressed by putting the sign of summation before every term in (242), (247), (252), and converting the summation on the left to a surface-summation by the introduction of $\mathbf{N}$, as in (243), (248), and (253), are examples of what is, in the Cartesian mathematics, called integration "by parts." It is usually a very tedious and uninforming process, that is, in Cartesians, with its triple and double $\int$'s, its $d\mathrm{S}$ and $dx\,dy\,dz$, and its l, m, n. The vectorial methods go straight to the mark at once, avoid a large amount of quite useless work, and enable you to keep your attention fixed upon the actual magnitudes concerned, and their essential relations, instead of being distracted by a crowd of coordinates and components.

There are, of course, many other cases which arise of this "by parts" integration. One of the most important in connection with the circuital series of vectors, is the following:— Substitute for p in the preceding, a vector, say $\mathbf{f}$, then we shall have

$$\Sigma \mathbf{f} \text{ curl } \mathbf{g} = \Sigma \mathbf{g} \text{ curl } \mathbf{f}, \quad . \quad . \quad . \quad . \quad (259)$$

the summations being throughout all space, or, at any rate through enough of it to include all the quantities summed. The proof is that since

$$\text{div } \mathrm{V}\mathbf{g}\mathbf{f} = \mathbf{f} \text{ curl } \mathbf{g} - \mathbf{g} \text{ curl } \mathbf{f}, \quad . \quad . \quad . \quad (260)$$

which is (178) again, we have, by space-summation,

$$\Sigma \mathbf{f} \text{ curl } \mathbf{g} = \Sigma \mathbf{g} \text{ curl } \mathbf{f} + \Sigma \text{ div } \mathrm{V}\mathbf{g}\mathbf{f}, \quad . \quad . \quad (261)$$

and the third term may be at once turned into the surface-summation $\Sigma \mathbf{N}\mathrm{V}\mathbf{g}\mathbf{f}$. If this vanish, as usual, then (259) follows.

Applying this result to the series of circuital vectors $\mathbf{A}_1$, $\mathbf{A}_2$, $\mathbf{A}_3$, &c., each of which is the curl of the preceding, we obtain various equivalences. Thus,

$$\Sigma \mathbf{D}_1^2 = \Sigma \mathbf{C}_1\mathbf{E}_1 = \Sigma \mathbf{B}_1\mathbf{F}_1 = \Sigma \mathbf{A}_1\mathbf{G}_1, \quad . \quad . \quad (262)$$

through all space. Operate on one member by curl and on the other by $(\text{curl})^{-1}$, to pass from one form to the next. Also

$$\Sigma \mathbf{D}_1\mathbf{E}_1 = \Sigma \mathbf{C}_1\mathbf{F}_1 = \Sigma \mathbf{B}_1\mathbf{G}_1 = \Sigma \mathbf{A}_1\mathbf{H}_1, \quad . \quad (263)$$

in a similar manner; and so on.

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In any of these summations we may convert either of the circuital vectors involved to a general vector by adding any divergent vector. For we see, by (259) that if $\mathbf{f}$ is polar, the right summation vanishes, and therefore so does the left. So $\Sigma \mathbf{D}_1^2$ is the same as $\Sigma \mathbf{D}_1\mathbf{D}$, or $\Sigma \mathbf{D}_1\mathbf{D}_2 = 0$. Similarly, $\Sigma \mathbf{C}_1\mathbf{F}_1$ is the same as $\Sigma \mathbf{C}\mathbf{F}_1$, or the same as $\Sigma \mathbf{C}_1\mathbf{F}$, since $\Sigma \mathbf{C}_1\mathbf{F}_2 = 0$, and $\Sigma \mathbf{C}_2\mathbf{F}_1 = 0$. It will be understood here that the suffix 1 refers to the circuital vectors entirely, and the suffix 2 to the divergent vectors, and that $\mathbf{C} = \mathbf{C}_1 + \mathbf{C}_2$, &c.

But we cannot generalise *both* vectors at the same time. Take $\mathbf{CF}$ for example. We have,

$$\Sigma \mathbf{CF} = \Sigma (\mathbf{C}_1 + \mathbf{C}_2)(\mathbf{F}_1 + \mathbf{F}_2) = \Sigma \mathbf{C}_1\mathbf{F}_1 + \Sigma \mathbf{C}_2\mathbf{F}_2, \quad (264)$$

so that the summation of the scalar product of the two divergent vectors now enters. The series of divergent vectors and their intermediate scalars have properties similar to (262), (263).

(To be continued.)

SAFETY FUSES.

BY CLARENCE P. FELDMANN.

The problem which I have tried to solve experimentally is simply the following. If for any set of terminals the fusing current for a fuse wire of given material, given diameter and given length be known, what empirical formula must be employed to calculate the fusing current for any other length of the same wire, clamped between the same set of terminals?

In his excellent Paper, "On the Relation which ought to Subsist between the Strength of an Electric Current and the Diameter of Conductors to Prevent Overheating," Prof. George Forbes* mentioned some experiments which he had made in 1881 to determine the fusing current of lead wires. The results he obtained are tabulated below. Finding that the fusing current for a wire of given diameter, d, increased very rapidly with decreasing length, l, Prof. Forbes pointed out that to avoid the cooling influence of the terminals, the length should be taken equal to three hundred times the diameter—

$$l = 300\, d.$$

At about the same time Mr. W. H. Preece† determined experimentally the current that raised the temperature of small conductors in air to the fusing point. In this, the first of his Papers, Mr. Preece had already pointed out‡ "how the cooling effects of the terminals or binding screws might vitiate the results, and how necessary it was to experiment on wires of sufficient length to prevent any error occurring from this cause." He used lengths of 6in. to determine the constants for wires free from the cooling effect, but lengths of 1¼in. with massive terminals to determine the constants for wires used in practice as cut-outs. Mr. Preece's last constant, a, for lead §, giving the current C required to fuse a wire of diameter d by the expression—

$$C = 1379\, d^{\frac{3}{2}},\ d \text{ being expressed in inches,}$$

$$\text{or } C = 10{\cdot}77\, d^{\frac{3}{2}},\ d \text{ being expressed in millimetres,}$$

has been widely used on the Continent under the latter form, without any statement that it was only strictly true for a certain minimum length.

In 1883 Reinisch ‖ fused lead wires of 2 mm. diameter of various lengths; but as he only intended to prove Joule's law by his experiments, the attention paid to his work was small. The first who approached a solution of the problem was a member of the Technical Society of the Russian Empire, whose name—Skrschinski—however, cannot easily be pronounced by an English tongue.

Skrschinski's Paper was read on December 17, 1890, and is published in the third number of the Russian journal, *Electritschestwo*, and Prof. Nicolai von Ozmidoff, of Riga, had the kindness to communicate me its contents. The Paper contains a great many valuable remarks and results of tests, only some of which, however, were confirmed by my own experiments. As to the diameter, Skrschinski proposes to take no lead wire under 0·5 mm. or over 2 mms., as the former is too easily torn to pieces, and the latter is apt to heat the terminals more than necessary, and to cause irregular action of the fuse, owing to the fact that in lapse of time wires of this and larger diameters will become made up of two co-axial parts; the interior of lead, the exterior of oxidised lead, which hinders the fusion, or with a too strong current, fuses with an explosion, scattering about the over-heated interior parts, which are fused long before the exterior ones.

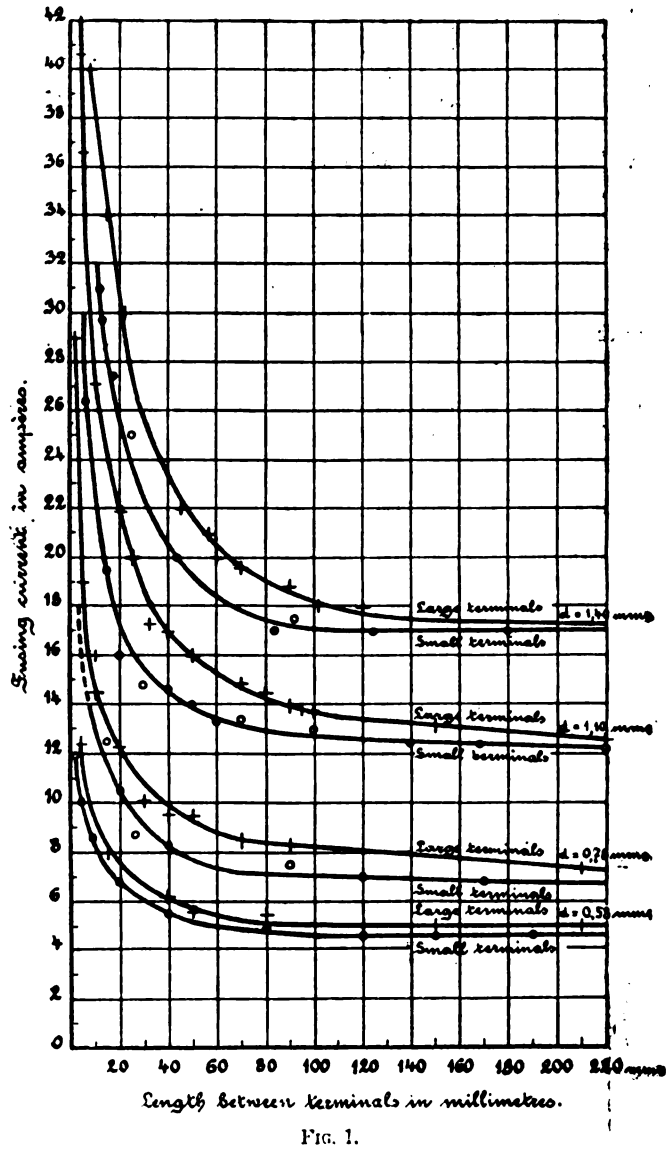

FIG. 1.

The wire always fuses midway between the terminals, and if the lengths are small, the cooling effect of the terminals suffices to let the lead wire become red hot, or even orange, corresponding to a temperature of nearly 1,000°C. Personally, I have never observed the orange-colour, though I used lengths from 400 mms. down to 2 mms., and I never happened to get red-hot wires with lengths over 1in., as Skrschinski did, though for lengths at or about ½in. and less the wire became gradually of a dark bluish grey, then of a dirty brown colour, till at last it was sending out light, like an incandescent lamp burning with a too low voltage.

In his experiments, Skrschinski determined the minimum current that would fuse a lead wire of given length and diameter, passing the current of a battery of accumulators through a liquid resistance, an ammeter and the fuse to be tested. My arrangement was nearly the same, only the resistance I used was of different construction, being built up of

* *Jour.* Soc. Tel. Eng. and El., Vol. XIII., 1884, p. 232. *The Electrician*, Vol. XIII., May 17, 1884, *et seq.*
† *The Electrician*, Vol. XII., April 12, 1884, p. 518.
‡ *The Electrician*, Vol. XX., Feb. 17 and 24, 1888.
§ *The Electrician*, Vol. XX., April 17, 1888.
‖ *Zeitschrift für Electrotechnik*, Wien., p. 243, 1883.

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Table I.—*Minimum Currents necessary to Fuse Lead Wires of d millimetres diameter and l millimetres length.*

Diameter *d*.	0·58.				0·78.				1·10.				1·40.			
Length between terminals.	Terminals.				Terminals.				Terminals.				Terminals.			
	Large.		Small.		Large.		Small.		Large.		Small.		Large.		Small.	
	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.
2 mms.	—	13·5	12·0	12·0	29·0	22·0	—	18·2	—	36·5	—	30·7	—	51·3	—	44·0
5 „	11·5	10·3	9·8	9·2	19·0	17·5	—	14·4	36·5	28·4	—	24·4	—	40·7	—	35·0
8 „	10·0	9·6	8·5	8·5	16·0	15·6	13·8	12·8	29·0	25·2	24·4	21·7	—	36·2	—	30·6
10 „	9·4	9·0	8·1	8·1	14·5	14·7	13·1	12·2	28·0	23·9	23·0	20·5	37·0	34·2	32·0	29·5
15 „	8·4	8·2	7·6	7·3	13·5	13·3	11·4	11·0	24·7	21·6	19·6	18·5	34·0	30·0	28·6	26·6
20 „	7·6	7·6	6·8	6·8	12·2	12·4	10·2	10·2	21·8	20·0	17·8	17·7	30·2	28·7	26·0	24·8
30 „	6·8	6·9	6·0	6·1	11·0	11·2	9·0	9·3	18·7	18·2	15·6	15·7	26·2	26·0	22·4	22·4
40 „	6·2	6·4	5·6	5·7	9·8	10·8	8·2	8·6	17·0	16·7	14·4	14·3	23·4	24·3	20·6	20·6
50 „	5·8	6·0	5·2	5·4	9·2	9·8	7·6	8·2	15·9	16·0	14·0	13·7	21·8	23·0	19·4	19·8
60 „	5·5	5·8	5·0	5·2	8·8	9·4	7·2	7·8	15·2	15·3	13·5	13·1	20·4	21·8	18·4	18·8
70 „	5·3	5·6	4·9	5·0	8·5	9·1	7·1	7·5	14·5	14·7	13·3	12·6	19·6	21·1	17·8	18·1
80 „	5·2	5·4	4·8	4·8	8·3	8·8	7·0	7·2	14·2	14·3	13·1	12·3	19·0	20·4	17·4	17·6
90 „	5·1	5·2	4·8	4·7	8·2	8·5	7·0	7·0	14·0	13·8	13·0	11·9	18·5	19·8	17·3	17·1
100 „	5·0	5·1	4·7	4·5	8·1	8·3	6·9	6·8	13·7	13·5	12·8	11·6	18·2	19·3	17·2	16·6
120 „	5·0	4·9	4·7	4·3	7·9	7·9	6·8	6·6	13·4	12·8	12·6	11·0	17·7	18·4	17·0	15·8
140 „	5·0	4·7	4·7	4·1	7·8	7·6	6·8	6·3	13·2	12·4	12·5	10·7	17·5	17·8	17·0	15·3
160 „	5·0	4·5	4·7	4·0	7·7	7·1	6·8	6·1	13·0	11·9	12·4	10·3	17·4	17·1	16·9	14·7
200 „	5·0	4·3	4·6	3·8	7·4	7·0	6·8	5·7	12·7	11·3	12·3	9·8	17·2	16·3	16·8	14·0

metal spirals that could be joined in parallel. Skrschinski found that for each of the wires he tested, the product of the length l into the square of the current C, $C^2 l$, was constant, being for—

$d = 0{\cdot}62$ mms.	$C^2 l = 2{,}325 = (9{\cdot}938)^4 \times d^3$	(for values of l > 9 mms. < 47 „)
0·82 „	$5{,}448 = (9{\cdot}97)^4 \times d^3$	„ „ — — „
1·10 „	$13{,}233 = (9{\cdot}986)^4 \times d^3$	„ „ > 20 „ < 60 „
1·55 „	$36{,}634 = (9{\cdot}96)^4 \times d^3$	„ „ > 18 „ < 71 „

so that he combines all his results in the approximate formula

$$C^2 l = 10^4 d^3.$$

This formula is remarkably simple, but I am sorry to say that it does not agree with the results I obtained, which are tabulated in Table I., and plotted out in the accompanying Fig. 1.

Table II. — *Minimum Currents necessary to Fuse Alloy Strips 0·5 millimetre thick, b millimetres wide, and l millimetres long.*

	$b=5$		$b=7$		$b=10$	
l	obs.	calc.	obs.	calc.	obs.	calc.
12	16·2	15·7	24·5	22·0	34·0	30·3
20	13·6	13·8	18·2	18·8	27·0	27·1
30	11·8	12·5	16·2	16·8	24·2	24·4
40	11·0	11·6	15·0	15·8	22·6	22·8
50	10·7	11·0	14·3	15·0	21·5	21·5
60	10·4	10·5	13·8	14·3	20·7	20·6
80	10·0	9·8	13·2	13·3	19·9	18·9
100	9·8	9·2	12·9	12·6	19·3	18·1
120	9·8	8·8	12·7	12·0	18·9	17·3
140	9·8	—	12·5	—	18·6	—
160	9·8	—	12·4	—	18·2	—
180	9·7	—	12·4	—	17·9	—
200	9·7	—	12·2	—	17·5	—

All the tests were made with two pairs of terminals, whose dimensions in millimetres and weights may be taken from Figs. 2 and 3. These terminals had not been made for the special purpose; they were taken from some apparatus, and this fact may account for the various borings which the drawings show. The material of the fuse wires was not pure lead, but some alloy of lead and bismuth. The approximation between the observed values of the fusing current and those calculated from the empirical formula,

$$C^2 \sqrt{l} = a \cdot d^3,$$

is as close as may be expected from the nature of the experiments, which, in themselves, show the remarkable fact that even if Skrschniski's formula be right for the terminals he used it will by no means hold good for anybody else's terminals.

From my own formula and for the terminals I used I found, with the large terminals (Fig. 2):—

$d = 0{\cdot}58$ mms.	.....	$C^2\sqrt{l} =$ 258	.....	$a = 1{,}320$
0·78 „	.....	650	.....	1,370
1·10 „	.....	1,850	.....	1,390
1·10 „	.....	1,850	.....	1,390
1·40 „	.....	3,500	.....	1,270
Mean value of a				1,350

with the small terminals (Fig. 3):—

$d = 0{\cdot}58$ mms.	.....	$C^2\sqrt{l} =$ 205	.....	$a = 1{,}050$
0·78 „	.....	460	.....	970
1·10 „	.....	1,350	.....	1,030
1·10 „	.....	1,350	.....	1,030
1·40 „	.....	2,700	.....	980
Mean value of a				1,000

or $C^2\sqrt{l} = 1{,}350\, d^3$ for the large terminals (Fig. 2),
and $C^2\sqrt{l} = 1{,}000\, d^3$ for the large terminals (Fig. 3).

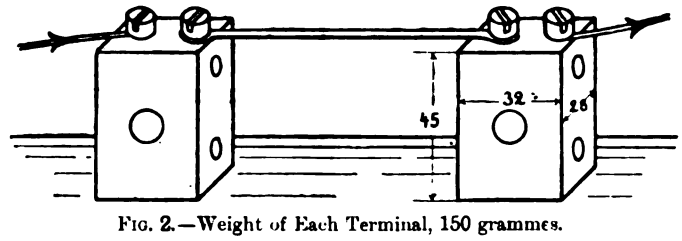

Fig. 2.—Weight of Each Terminal, 150 grammes.

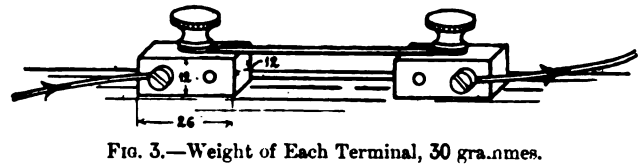

Fig. 3.—Weight of Each Terminal, 30 grammes.

Taking $l = 6$ inches, and measuring d in inches we have

$C = 1{,}340\, d^{\frac{3}{2}}$ for the large terminals and the alloy wires,

$C = 1{,}155\, d^{\frac{3}{2}}$ for the small terminals and the alloy wires, whilst Mr. Preece gave

$C = 1{,}357\, d^{\frac{3}{2}}$ for his terminals of medium size and lead wires;

If I may quote the authority of Prof. George Forbes, I should like to point out that some of his results of 1881 are practically in consonance with the empirical law $C^2\sqrt{l} = a \cdot d^3$. Prof.

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Forbes gave for a lead wire of 1·28 mms. diameter the following series of observations :—

$l = 300$ mms.	.....	$C = 9{\cdot}05$	$C^2\sqrt{l} = 1{,}555$
150 „	.....	12·37	1,870
75 „	.....	12·75	1,410
50 „	.....	13 5	1,290
25 „	.....	16·87	1,425
Mean value of $c^2\sqrt{l}$ =	.....		1,500

from which, however, a would only be about 715. As the results were three years old when Prof. Forbes published them,

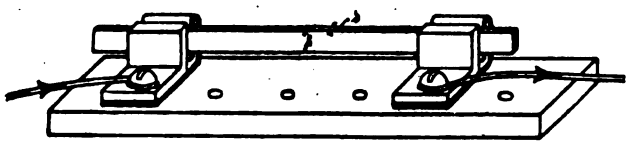

Fig. 4.—Weight of Each Terminal, 30 grammes.

it is possible that there may be some slip in the diameters. This view seems to be supported by the fact that in the rest of the table

$d = 0{\cdot}55$ mms.	...	$l = 25$ mms.	...	$C = 0{\cdot}78$	amperes.
0·78 „	...	25 „	...	0·937	„
0·94 „	...	25 „	...	1·125	„
1·03 „	...	25 „	...	8·2	„
1·03 „	...	225 „	...	6·0	„

either the small diameters or their corresponding fusing currents are obviously wrong.

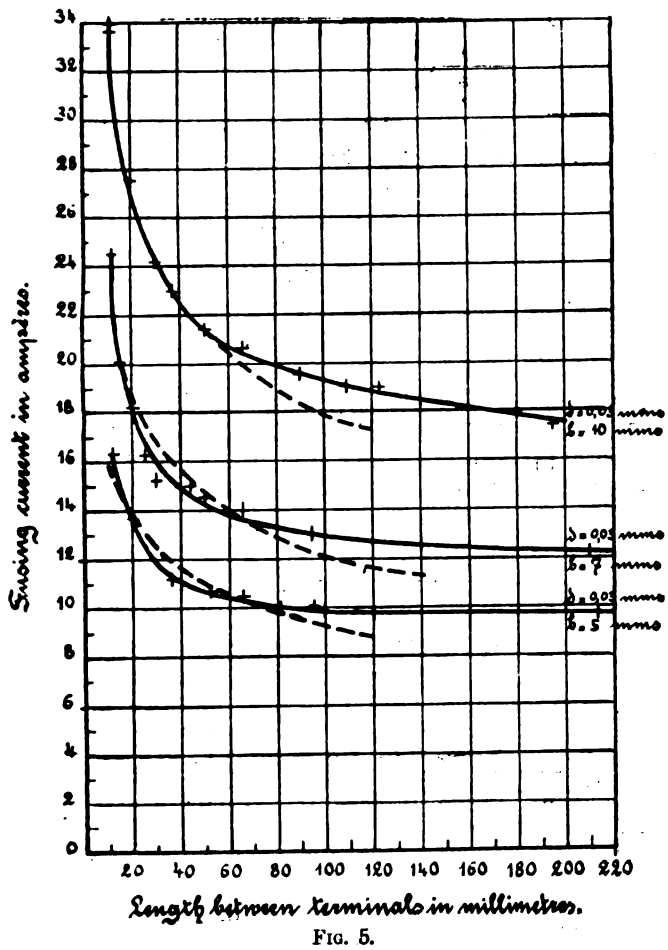

Fig. 5.

I have also experimented upon fuses in the form of strips shown in Fig. 4. The empirical law $c^2\sqrt{l} = a\,S$, if we denote by S the surface of the strip, holds good in this case too, but its range is narrower than with round wires. The tests were made with strips $\delta = 0{\cdot}05$ mms. thick, and b various widths, $b = 5$, 7 and 10 millimetres; two of these strips were fastened with shellac varnish upon the sides of a thin strip of cardboard of corresponding width. The results are given in Table II., and are plotted out in Fig. 5, where the dotted lines show the calculated, the full lines the observed fusing currents. The currents were calculated from the values

$C^2\sqrt{l} =$	849 for	$\delta = 0{\cdot}05 \times 2$ mms., and	$b =$	5 mms.	wherefrom	$a = 332$
$C^2\sqrt{l} = 1{,}580$	„	$= 0{\cdot}05 \times 2$ „	„	$= 7$ „	„	$= 318$
$C^2\sqrt{l} = 3{,}271$	„	$= 0{\cdot}05 \times 2$ „	„	$= 10$ „	„	$= 327$
Mean value of a						$= 326$

The approximation obtained by the empirical formula,

$$\therefore\ C^2\sqrt{l} = 326 \times b\,2\,\delta\,(b + 2\,\delta),$$

is, however, less than in the case of round wires.

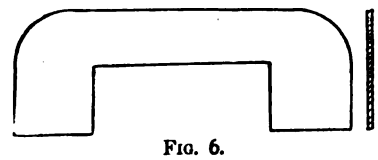

Fig. 6.

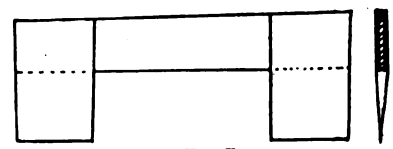

Fig. 7.

The influence of a small change in the terminals was shown by a simple experiment. Two sets of fuses of exactly the same dimensions l, b, and δ were tried, of which one had been provided with a small wrapping of brass sheet round the ends. (Figs. 6 and 7).

Dimensions of strip.	Bare strip.		Strip with enlarged ends.		Terminals.
$\delta = 0{\cdot}05$ $b = 8$ $l = 24$	J = 20	$a = 302$	J = 23	$a = 400$	Smaller than Fig. 7.
$\delta = 0{\cdot}075$ $b = 10$ $l = 37$	J = 29	$a = 334$	J = 34	$a = 460$	like Fig. 4.

The weight of each of the terminals smaller than those represented in Fig. 4, was 10 grammes, the weight of each of the other terminals was 30 grammes.

By my experiments I only think I have proved that it is absolutely necessary to test fuse wires exactly under the conditions of their normal use, within the clamps that are to hold them, these clamps being fixed upon the proper base, and the whole fuse being covered with a metal or porcelain cover, as in practical use. There is no doubt that, with open fuses, convection plays a prominent part in the "going" of a fuse, and that a fuse in cold open air will take a higher current than a fuse of similar size near the ceiling of a hot engine-room.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, May 27th.

LONDON CHAMBER OF COMMERCE.

2.30 p.m. Annual Meeting of the Electrical Trades Section at Botolph House, Eastcheap.—The agenda will be found in our "Notes" column.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Paper to be read: "On the Present State of our Knowledge of the Connection between Ether and Matter.—An Historical Summary." By Prof. O. J. Lodge, F.R.S.

OLD STUDENT'S ASSOCIATION.

7.30 p.m. Smoking Concert at Masons' Hall Tavern.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Emotional Expression." By Sir James Crichton-Brown, F.R.S.

TUESDAY, May 31st.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Annual General Meeting to receive the Report of the Council, and to elect the Council and Officers for the ensuing year.

SOCIETY OF ARTS.

8 p.m. Applied Art Section. Paper to be read: "Lustre Ware." By William de Morgan.

FRIDAY, June 3rd.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Metallic Carbonyls." By Ludwig Mond, F.R.S.

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The Electrician.

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TRAIN-LIGHTING.

Of the three systems of train-lighting—direct driving from a small engine; discharge from accumulators without engine or dynamo; and dynamo driving from an axle—the last seems to be the most promising. Accumulators are necessary to supply the lights not only while the train is at rest, but when it is running at a speed too slow to drive the dynamo at a useful voltage. The charging of the batteries is effected only while the train is running above this speed, and, of course, only during the daytime. The ratio of the period during which charging is possible to the period during which the batteries are called upon to supply the current determines the minimum speed. This varies widely on different lines, and with different trains and classes of trains. Neither engineers nor traffic managers are able to give accurate information on that point, and several failures have been due to neglect of this consideration. Increase of speed above the minimum does not contribute any useful effect, but has to be neutralized by the action of a governor introducing resistance in the fields, or rocking the brushes; or by some other means for preventing a rise of the voltage, such as a second dynamo, or compound winding with back turns. Such a governing apparatus has only a limited range, and varies from one to three or one to four. The HOLMES' double dynamos on the Midland Railway cut in when 25 miles an hour is attained, and maintain a constant pressure of 50 volts up to 75 miles an hour. The full pressure is thus attained at one-third of the maximum speed. The governing arrangement of Mr. HOUGHTON, of the London, Brighton, and South Coast Railway Company, adapted to a Brush dynamo, enables the dynamo to begin to generate at one quarter of the full speed. If this were equivalent to the effective working of the dynamo during two-thirds or three-quarters of the whole of the journey there would be little or no difficulty. It is not a question of mere speed, for the gear could be adapted for either fast or slow trains; but the difficulties arise with trains stopping at many stations, when it will be found in a large number of cases that the period during which charging is possible is

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less than that during which the batteries are called on to provide current, unless a very wide range of working of the dynamo is arranged for. With a wide range the dynamo must be larger, for it must be able to do the whole work at a slower speed. Another difficulty arises when trains have to be broken up; the batteries are then subjected to unequal charge and discharge, and unless there is very ample provision for charging they are sure to deteriorate.

A year ago there were sixteen electrically lighted trains on the Brighton line, and six more were being fitted; on the Great Northern there were six, and two were being fitted; and on the Midland there were eight main-line and two local trains, making, according to Mr. LANGDON'S Paper on the subject, a total of 365 coaches and 57 vans electrically lighted. The Brush Electrical Engineering Company have supplied some 60 dynamos for train lighting which may be said to have advanced well beyond the experimental stage. Notwithstanding the success and increase of this branch of electric lighting, it must be remembered that it presents most unusual difficulties, and should not be attempted, as has often been done, without most careful consideration of the conditions of each particular service. The early attempts in this direction were sometimes entrusted, after they had left the hands of the contractors, to the supervision of telegraph superintendents, who, unlike Mr. HOUGHTON and a few others, knew nothing of dynamos or accumulators.

The various advantages which electric light presents in domestic illumination are not felt in train lighting, since the products of combustion of either gas or oil lamps are got rid of; and no accident has yet resulted from the use of compressed gas. The lighting of the London and North-Western trains running from the Mansion House to Broad-street is hard to beat; but the gas is very costly, and an expensive generating and charging plant has to be provided. It is remarkable that the value of electric lighting in connection with the two great systems of steam locomotion should differ so widely. It is simply indispensable on passenger steamers, where it is the greatest boon, and if the cost were double it would make little or no difference; and it is, moreover, easy to arrange and fit, there being no need for batteries or regulation. In passenger trains, on the other hand, the difficulties are peculiar, the mechanical and electrical details are very complicated, the light presents no advantages to the passengers, and the whole thing is simply a question of relative cost.

OBITUARY.

PETER WILLIAM WILLANS.

It is with deep regret that we have to announce the death of Mr. P. W. Willans, founder and head of the firm of Willans and Robinson, of Thames Ditton. Mr. Willans was driving from his residence at Frimley on Monday afternoon to his works, when the horse bolted and threw him on to a heap of stones, causing instant death from concussion of the brain. Mr. Willans was 41 years of age.

At 16 he entered upon a five years' apprenticeship in the shops and drawing office of Messrs. Carrett and Marshall (now Hathorn, Davey and Co.), engineers, Leeds, and spent two years chiefly in the drawing office of Messrs. John Penn and Sons, of Greenwich. Whilst with this firm he invented the first form of his three-cylinder high-speed engine, which was patented in 1874, the earlier examples being made by Messrs. Tangyes and Messrs. Hunter and English. From 1875 to 1880 he superintended the manufacture of his engines at the works of the latter firm at Bow. Mr. Willans soon saw that in order to develop the high-speed direct-acting engine to its fullest extent, it was necessary to start works of his own; and in 1880, in partnership with Mr. Robinson, the works at Thames Ditton were commenced from small beginnings, the business being at first confined to launch and yacht engines. The application of the Willans engine to the direct driving of dynamos caused the rapid development of the works; and though the business received a check when a fire destroyed the erecting shops, the reconstruction of the premises gave Mr. Willans an opportunity for putting down a most perfect example of an engine-manufacturing plant. The conditions demanded for the driving of dynamos have done much to improve the design and construction of steam-engines in this country; but many a valuable lesson has been learned by dynamo builders in the works at Thames Ditton, and many important developments have originated from the opportunities afforded by the careful testing which has been carried out there.

Although Mr. Willans' name is best known in connection with the manufacture of a particular form of engine, his early death is to be deplored on account of his knowledge of the application of thermo dynamics to the economical use of steam. His Paper on "Non-condensing Steam Engine Trials," read before the Institution of Civil Engineers on March 19, 1888, dealt with only a few of the important points of which he had so thorough a grasp; and we understand that he has left another Paper on the subject. Though he could find little time to write elaborate Papers, the part which he took in discussions at the Institution of Civil Engineers and elsewhere revealed how much he might have communicated. His remarks after Mr. Imray's Paper on "High Speed Motors" on November 24, 1885, Mr. Allen's Paper on "Auxiliary Engines" on January 13, 1891, and after Mr. Crompton's Paper on "The Cost of the Generation and Distribution of Electrical Energy" on April 7, 1891, were of the greatest value. Though not unfrequently finding himself opposed to rival manufacturers, he never was heard to make an unkindly remark or criticism of the work of others. In discussing Mr. Allen's paper on "Auxiliary Engines," he referred to a fan engine at the Woodthorpe Colliery, which had been at work for five years. It had run as much as nine months without being stopped, and it was locked up by itself at night. His partner being down there on one occasion, asked to be allowed to see the engine. He was told that the man had gone home and had taken away the key.

The high economy attained by his engines when used for electric lighting plant is so well known and so universally acknowledged, that it is unnecessary here to enlarge upon it; but it is perhaps not so generally known that the main cause of these great successes was the care and forethought with which Mr. Willans himself adapted his machinery to suit the special requirements and special needs of the rapidly developing industry. The great mechanical success of the Willans engine has done much to establish confidence in high-speed driving among engineers; but this alone would not have established the reputation which the inventor has built up. Proud as he was of the silent running and excellent wearing qualities of his engines, due to careful design and the best workmanship, the real aim of his work, as far as may be judged at present, was economy of steam; and in this is included not only the use of direct-driving and doing away with belts and counter-shafting, but the management of boilers, the proper use of condensing, and the selection of the size of unit of plant for particular conditions. He lived, fortunately, to see the successful application of his work to mill-driving; and at a recent meeting of the Society of Arts, described during a discussion how the starting of an engine of about 659 H.P. in a cotton-mill at Bolton was really child's play to what an electric light engineer had to do, it was so simple, in comparison; showing, perhaps, what a high view he took of the proper carrying out of the driving of dynamos.

In private life Mr. Willans' character was a very perfect one. His kindliness of nature and thoughtfulness for others will cause him to be long and regretfully remembered by his large circle of friends; but the loss which electrical engineering has sustained by his death will be only estimated at its full value when those who have so long worked with him and profited by his advice begin to feel that they no longer have him with them to aid them.

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NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 6.*)

[**Erratum.**—In the reference to Mr. Webb on page 5, *The Electrician*, May 6, in connection with the underrunning of cables, an error was inadvertently made in the initials to the name, which we hasten to correct by saying that the name should read Mr. F. C. Webb.]

10. Capacity of Tanks.—To obtain some idea of the general carrying capacity of a repairing steamer, take for instance a vessel such as the "Electra," belonging to the Eastern Telegraph Company, the tanks in which are of the dimensions given above. Consider first the largest tank (No. 2), the position of which with regard to the section of the ship is indicated in Fig. 30. The upper edge of the tank is just below the main

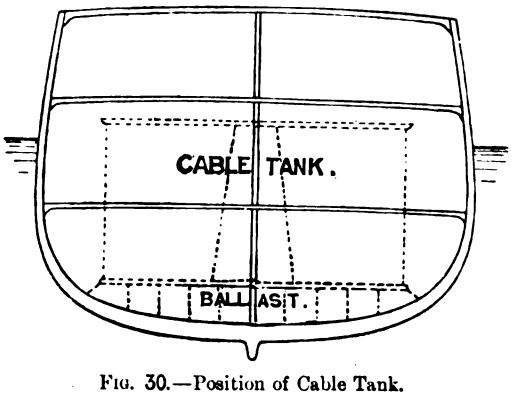

FIG. 30.—Position of Cable Tank.

deck, and the bottom rests upon the water ballast tanks, the height being 12ft. The cone is 6ft. diameter below and 3ft. above, so that considering the tank two thirds full of cable the diameter of the cone at the topmost flake would be 4ft., and the mean inside diameter between this flake and the lowest one would be 5ft. (Fig. 31). The tank being two-thirds full will be filled to a height of 8ft., and it will be necessary first to calculate the cubic capacity of the tank up to this level, exclusive of that of the cone. The capacity of the cone to the level of 8ft. is

$$(5)^2 \times 0{\cdot}7854 \times 8 = 157 \text{ cubic feet,}$$

and the tank being 25ft. diameter its capacity up to same height is

$$(25)^2 \times 0{\cdot}7854 \times 8 = 3{,}927 \text{ cubic feet.}$$

Deducting the capacity of cone, we have 3,770 cubic feet available coiling space.

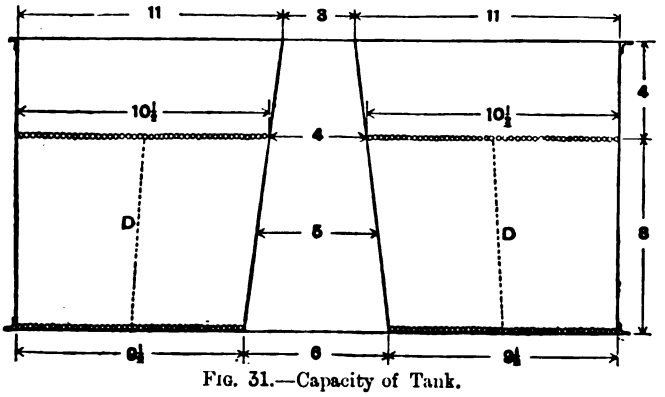

FIG. 31.—Capacity of Tank.

Now suppose that the cable coiled in is the deep sea type, this being the kind of which the largest quantity is required. The overall diameter is as closely as possible ¾in. ($\frac{1}{16}$ foot), and, therefore, the cubic contents or capacity of one knot of this type is equal to

$$(\tfrac{1}{16})^2 \times 0{\cdot}7854 \times 6{,}087 = 18{\cdot}67 \text{ cubic feet.}$$

We have now to consider the space this cable occupies when coiled in tank. It is quite clear that between each turn of cable there are spaces left unutilised, on account of the circular cross section of the cable. The proportion of this waste space varies according to the size of cable, and it is found that an allowance has to be made of from 10 per cent. in small cables to about 25 per cent. in large types for this unoccupied space. After the cable has been stowed in tank for some time it settles down, and the waste space is diminished, the decrease amounting sometimes to 5 per cent.

There is also some extra space taken up by the feather-edge in coiling (Fig. 32). The cable is coiled from the outside of the tank inwards, and when the innermost turn of one flake is laid next the cone the cable is taken straight across over this flake to the outside to commence coiling the next flake. The part so taken across and lying between each flake is called the "lay-out," and in the figure is shown in section by the small circle. The feather-edge is made with strips of deal wood about five or six feet long, and cut with a wedge-shape section, as shown, so as to pack up the lay-out and form a gradual rise and fall for the turns of the upper flake as they cross it. For the deep sea type which we are now considering, a fair allowance to make for waste space in coiling is 15 per cent.—that is, one knot of this cable, which contains 18·67 cubic feet, as calculated from its own dimensions, would, when coiled, take up 15 per cent. more space, or 21·47 cubic feet. The length of cable in this tank when two-thirds full is now easily calculated. The available space being 3,770 cubic feet, and the space taken up per knot being 21·47 cubic feet, the length coiled in is

$$\frac{3770}{21{\cdot}47} = 175 \text{ knots.}$$

In a similar manner the forward tank (No. 1), which is 14ft. diameter and 8ft. deep, when two-thirds full would hold 33 knots of the same type, and the two tanks aft, both about 17ft. diameter and 7ft. deep, would each contain 45 knots. Thus, with all four tanks only two-thirds full, a vessel of this size (1,096 tons) could carry 298 knots of deep sea cable. The cubical capacity, exclusive of cone, is usually worked out for different heights in the tank, separated by very short intervals, so that at a moment's notice the approximate length of any given type coiled in can be ascertained.

FIG. 32.—Feather edge in coiling.

In picking up during repairs the lengths coiled in tank generally only occupy a few flakes, and it is often desirable to know the length of cable per flake for different types, as coiled in each of the tanks. This may be observed, as the cable is being coiled, by the indications of the rotometer, but is also very readily calculated. Taking, for example, the above tank (Fig. 31), there will be 168 turns of cable to the topmost flake, since the width across from cone to outside of tank is 10ft. 6in. (or 126in.), and the cable is ¾in. diameter: hence

$$\frac{126 \times 4}{3} = 168 \text{ turns.}$$

Further, the mean length per turn is found by multiplying the mean diameter of the flake by 3·1416, and the mean diameter is found by taking half the sum of the diameters of cone and tank at that height. Thus, the flake, at the height of 8ft. in the tank, has a mean diameter of

$$\frac{4+25}{2} = 14{\cdot}5\text{ft,}$$

and this, multiplied by 3·1416, gives 45·55ft. as the mean length of cable per turn. Hence, the length of cable per flake is

$$168 \times 45{\cdot}55 = 7{,}652\text{ft. or } 1{\cdot}257 \text{ knot.}$$

The mean diameter increases slightly down to the lowest flake, as shown by the lines DD, on account of the cone; hence, the mean length per turn increases: but, at the same time, the number of turns per flake decreases more rapidly, and the length of cable per flake is consequently less, the lowest flake, by a similar calculation, containing 1·216 knot. The above figures represent very closely the cable-carrying capacity of repairing steamers of the average tonnage; but, before leaving

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the subject, it may be of interest to consider the capacity of one of the largest cable steamers afloat. These steamers, which are from 3,000 to 5,000 tons, are of sufficient capacity to take out whole cables of one to two thousand miles long in one shipment, with all the necessary gear and accessories required in such large undertakings. Besides this, they are able to carry a coal supply sufficient for four or five months' continuous work. The cable ship "Scotia," of 4,667 tons, some time ago performed four months' cable work in the Atlantic, returning afterwards with 1,100 tons of her original stock of coal. The cable ship "Silvertown," of 4,935 tons, when on the Central and South American expedition, carried 4,881 tons of cable, 1,660 tons of coal, 111 tons of buoys, chains, cable-gear, and office and telegraph fittings, and 159 tons of provisions and water, making a total of 6,811 tons. The above weight of cable represented a length of 2,370 knots, the same vessel having carried as much as 2,600 knots on one trip. Of vessels of this description our nation may be justly proud. Their magnificent and powerful build, their enormous cable and fuel capacity, their heavy equipment of grapnels, chains, buoys, brakes, and steam-gear for ocean work under the heaviest strains; their light equipment of electrical apparatus, in the design of which the highest scientific skill has been brought to bear—all tend to mark such vessels as grand floating monuments to the enterprise, the pluck, the dogged perseverance, the scientific ability, and the high engineering and nautical skill of the greatest maritime nation in the world.

One of these fine cable ships, the "Silvertown," belonging to the India Rubber, Gutta Percha, and Telegraph Works Company, is illustrated herewith from a photograph (Fig 33). She is 350ft. long, 55ft. broad, and 34ft. 6in. deep, is fitted with engines of 1,800 I.H.P., and steams at a speed of 10½ knots, with a consumption of 30 tons of coal per day. She carries three tanks of large proportions, each one being 32ft. in depth, and the largest (the main tank) being 53ft. in diameter. This tank has consequently over 70,000 cubic feet capacity, or about 67,000 cubic feet exclusive of the cone. When filled with cable up to the height of 29ft. the coiling space, exclusive of the cone, is 61,221 cubic feet, the space taken up by the cone at this height being 2,758 cubic feet.

Now, we found above that one knot of deep sea cable occupied 21·47 cubic feet of coiling space, and, therefore, the "Silvertown's" main tank will hold

$$\frac{61221}{21{\cdot}47} = 2{,}850 \text{ knots}$$

when filled to the height of 29ft.

The fore tank on this vessel in 46ft. in diameter and the aft tank 51ft. It is not usual to load up the tanks more than to a depth of 23ft., or about two-thirds full, except for cables of a light and bulky type.

For readily computing the lengths of cable stowed in tank, the capacities of the tank and cone at various heights are kept for reference, and marked on a large elevational drawing of the tank. It is then only a matter of observation, while coiling, of the height to which the tank is filled, and knowing the capacity of each type of cable and the space it occupies when coiled, the length stowed in tank is at once obtained by simple division. The light intermediate type has a capacity of about 40 cubic feet per knot, and occupies about 46 when coiled; the heavy intermediate has about 58 cubic feet per knot and 78 as coiled; and the shore end type has about 185 cubic feet per knot and 230 when coiled.

When carrying 6,390 tons the mean draught of the "Silvertown" is 28ft, and with the load of 6,811 tons alluded to above, her draught was 27ft. forward and 29ft. 6in. aft, the greatest draught of any merchant steamer except the "Great Eastern." The coal bunkers on board have a combined capacity of 1,300 tons, besides which over 1,000 tons can be stowed in the fore hold. With such a stock of fuel this vessel can steam greater distances and remain continuously at work without coaling for longer periods than any other existing cable ship. The "Silvertown" is now at sea laying the new cable between St. Louis, Senegal, and Pernambuco, for which expedition she left the Thames a few days ago with 2,160 knots of mixed cable, including shore ends, and representing a dead weight of 5,000 tons.

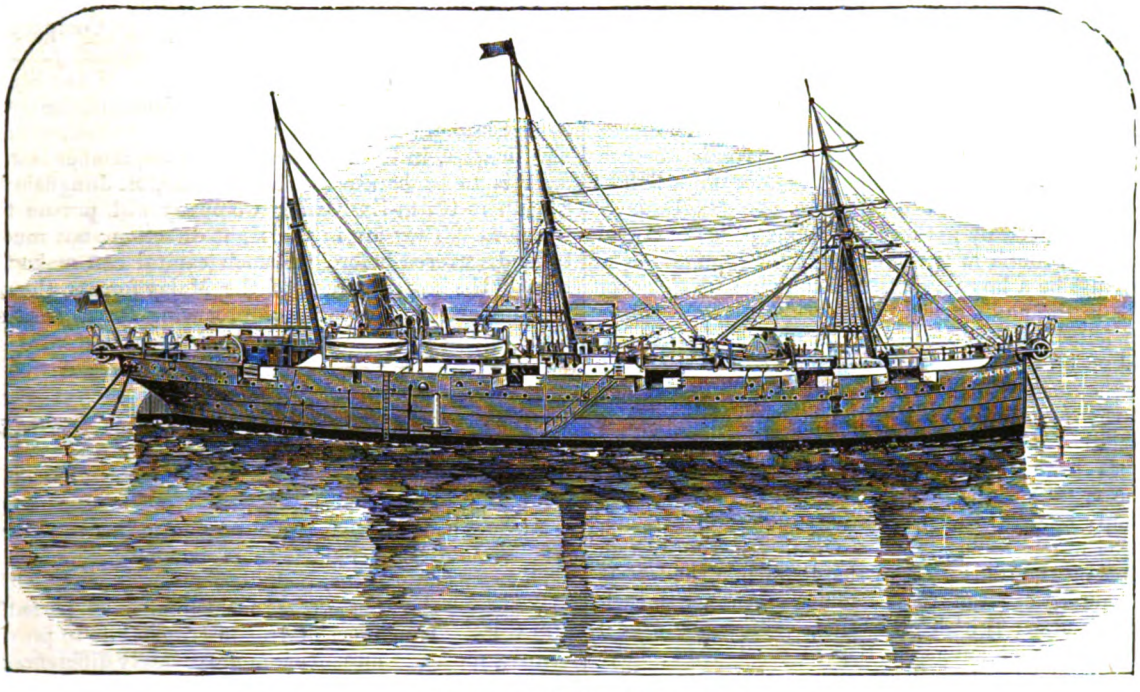

FIG. 33.—Cable Ship "Silvertown.

(To be continued.)

THE CULTIVATION AND COLLECTION OF GUTTA-PERCHA.

Under the above heading we gave in our issue of May 20th an epitome of a report made by M. Eugène Sérullas to the Société d'Encouragement on his latest expedition to Malaysia to investigate the gutta-percha supply.

The question of the supply of gutta-percha is a large and important one, of the deepest interest to all who are connected with the *use* of electricity; and any contribution to our knowledge of its supply, or the sources of its supply, which is authentic and reliable, will be cordially welcomed. If M.

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Sérullas has discovered means for "the regeneration of exhausted sources" it goes without saying that his name and fame are assured. To the present writer, a few months ago, one of the highest authorities at Kew Gardens said, "We know extremely little about the trees which produce the gutta-percha of commerce;" and this statement was fully demonstrated when he exhibited the specimens of *isonandra* preserved in the Museum, which were a few dried leaves bearing legends dating from 1834 to 1858.

Authorities do not agree as to the origin of the name *gœta*, *guettah*, *getah*, or *gutta*; nor are they agreed to whom the honour is due of being the first European to bring to Western notice the elastic vegetable gum used by the Malays for weapons of war or vessels of domestic use. But all authorities agree that the present method of procuring this gum is wasteful in the highest degree, and has naturally resulted in denuding the forests in all easily accessible places of the Malay Peninsula of their richest jungle tree.

Gutta-percha has been known to European commerce for 60 years; and for 35 to 40 years there has been a large and increasing demand, which to-day is satisfied, as it was 40 years ago, by the Chinese middlemen employing the Malay natives to range the jungle, and either (1) cut the trees down if they are sufficiently large, "ring" them, and gather by rapid process the exuding sap from the trunks and large branches. (2) If the trees are too small to yield a sufficiently large harvest to repay the time in felling, to pierce them in a few places and collect by slow process the exuding sap. In the former case the tree is felled close to the ground; at about every 12 inches on the trunk and larger limbs a V-shaped groove is notched through the bark right round the trunk; the juice immediately appears and coagulates into a dull white viscid substance, which the natives collect by gathering a little pellet of it and rolling it round and round in the groove till the gum ceases to flow. There must be a large quantity of the gum which never leaves the cells in the undisturbed bark. In the latter process the tree is not felled. Holes are bored by an augur irregularly over the trunk, a bit of palm leaf or part of a cocoanut shell is fixed to catch the gum. These borings must eventually damage the tree, and the quantity gathered from these small trees is exceedingly small. Naturally all the forests in civilised and settled Malaysia have been exploited. In the three colonies that form the Straits Settlements, Singapore, Penang, and Malacca, the only *isonandra* to be found are under 30 years old, too young to be worth felling for the yield. In the British protected States on the south-west of the Peninsula the forests are similarly denuded of large trees. Pahang, on the north-east, has, since it came under British protection, offered a new field for "gutta getters," and gangs of Borneo coast tribes have turned their attention to these Pahang jungles during the past two years, and have pursued their wasteful method with fairly good results. Borneo has all along produced the greatest quantity of Straits gutta, and its enormous extent of jungle country still promises for some years to keep up the supply. But naturally this must be gathered farther and farther from the coast.

Mr. Collins, late curator of the museum in Singapore, and Mr. Wray, curator of the Perak museum, have greatly contributed to our knowledge of the varieties of the *isonandra*, and of the methods of procuring and preparing the gum for the market. Through the representations of the latter the State Council of Perak a few years ago prohibited or considerably restricted the reckless felling of gutta trees in that State. The policy of *laissez aller* had prevailed too long in the three British Settlements and the other Protected States; there were very few trees left, and these only young. No effort has been made anywhere throughout Malaysia to propagate, cultivate, or plant the tree.

M. Sérullas' name is familiar as a frequent contributor to French scientific journals on the chemistry of gutta-percha. He has been at various times during the past ten years charged with a mission by the French Government to investigate the cultivation of gutta-producing trees and other tropical produce, with the object, as far as regards gutta, of introducing the tree into Cochin China and Algeria. Cuttings and seedlings were procured in and around Singapore, and their cultivation was attempted near Saigon, but the attempt was a failure. The *isonandra* refused to grow beyond 6deg. from the equator, and we have not heard of any Algerian plantation.

And here the writer may controvert two statements made in the extract from M. Sérullas' Paper. First: It is true that the leaves and branches of a young tree are richer in coagulated milk than those of an old tree, but it has yet to be demonstrated that this coagulated milk of the young tree contains the adhesive, elastic, and insulating properties of the milk of the older tree. Secondly: A gutta-percha tree is not valueless to a native from being *too old*. It is never too old to lend itself to "trunk working," by which we understand the process of felling and ringing described above.

About twelve months ago M. Sérullas formed a small company in Singapore to develop and work a process for the extraction, by chemical means, of the gum from the young branches, shoots, and leaves of the *isonandra gutta*. The chemical process followed was probably that "suggested" to M. Sérullas by M. Jungfleisch. A factory was established, branches and leaves were gathered in the adjacent jungle, and up to July of last year about 7lb. or 8lb. of gutta-percha were produced. This percha has been submitted to experts in England, and is found to be deficient in elasticity, to be short, brittle, having in excess the *resinous* gum which is common to most tropical trees. The Singapore Gutta-Extracting Company promised to revolutionise the supply of that commodity. A report on the "local industry" from the Governor of the Straits Settlements was considered by Lord Knutsford sufficiently important to be communicated to Kew, and was embodied, with other relevant matter, in the *Kew Bulletin* for September last.

It is to be hoped that M. Sérullas, M. Jungfleisch, and the Singapore Gutta-Extracting Company will pursue their investigations. They are in the right direction; but much remains to be discovered before "French capital can make the utilisation of the last resources of the Malay forests the object of a vast undertaking, capable of procuring for it great and immediate profits."

SOME "THOMSON" ELECTRICAL MEASURING INSTRUMENTS.

Although but few electrical measuring instruments are to be seen at the Crystal Palace, there is a very complete exhibit of "Thomson" apparatus, including an improved gold-leaf electroscope for the approximate measurement of potentials above 500 volts. The object of this instrument is to provide a convenient means of measuring approximately differences of potentials in cases where the accuracy of an electrometer is not required, and where its consequent expense would be a serious consideration. Only one narrow gold leaf is used, and this is attached by a clamp to a broad plate of brass. This brass plate is supported on a block of vulcanite from the roof of the case, and has a binding screw attached to it. The case of the instrument—with the exception of the front, which is of glass—is of metal, and the portion below the leaf is cylindrical in shape, so as to obtain from its inductive action a wide range of sensibility. A scale is engraved upon the back of the case, and another is placed in front close to the glass, in order that the deflections of the instrument may be read off without error due to parallax. A hinged frame is attached to the repelling plate, which folds down over the leaf to prevent damage during carriage, and when turned up it acts by repulsion as a guard which effectually prevents the leaf from touching the roof of the case at abnormally high potentials. The instrument may be used as a constant indicator to test the equality of the pressures between earth and each of the two primaries of a high-tension system.

Another piece of apparatus is an electric watt balance for the measurement of currents up to 10,000 amperes. These electric watt balances were designed in the first instance to meet the requirements for a standard balance to read up to 10,000 amperes. For this purpose it was not considered advisable to use the ordinary *idiostatic* "Thomson" balance, on account of the necessarily enormous proportions

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which the movable beam would have, and the consequent limitation of range due to possible stiffness in the suspending ligament. The instrument was therefore designed on the plan of the composite balance, in which the main current passes through heavy copper conductors, while a small current of measured amount is passed through two coils of fine wire at each end of a movable beam in every way similar to that of the "Thomson" centi-ampere balance. The main conductor is shaped like a double rectangle, as shown in Fig. 1, and the current is conducted in by one electrode round three sides of the top rectangle, then down by a connecting piece at *a* round three sides of the bottom rectangle, and out by the other electrode. The beam, with its movable fine wire coils, is situated between the two rectangles, and its terminals are brought to two binding screws shown at *b*. The action when the current is passing is the same as in the other "Thomson" electric

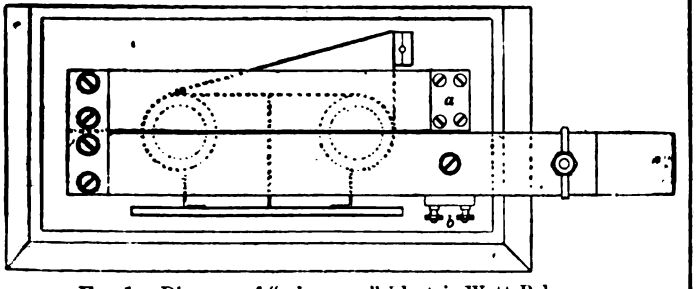

FIG. 1.—Diagram of "Thomson" Electric Watt Balance.

balances. The conducting rectangles are each made of a thick copper plate, with a slot about 0·5c.m. wide cut from the right-hand side up to within 9cm. of the left-hand end.

The instrument is, of course, a self-contained watt-meter, and when it is to be used as such extra resistances are provided for the fine wire circuit. The resistance of the fine wire coils is about 10 ohms, and the extra resistances provided are subdivided into coils of 400 ohms each, so as to permit of an adjustment of the instrument's constant from 50 to 2,000 watts per division of the scale. When the instrument is used as a standard ampere balance the current values can be obtained by dividing the watt readings by the electromotive force if a reliable voltmeter is available; but for very accurate working it is best to measure the actual current passing through the fine wire coils on an auxiliary instrument, such as a centi-ampere balance. By this method great sensibility can be obtained, as currents up to one ampere can be used, and so the constant of the instrument can be varied at pleasure from 0·1

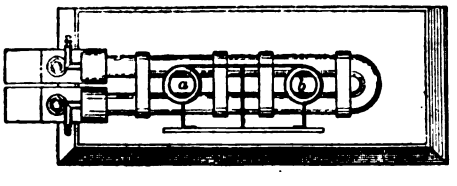

FIG. 2.—Diagram of "Thomson" Alternate-Current Kilowatt Meter.

ampere to 10 or 20 amperes per division of the scale; and thus a range of measurement from 0·1 to 12,000 amperes is provided. The balance, as described above, is intended for use with continuous current, and it is evident that an instrument of this kind, if used with alternating current, would require a special constant to suit different periods of alternation.

To suit cases where the testing is either on direct or alternating systems a different type of instrument, called the alternate-current kilowatt meter, with a stranded main conductor, is made. The instrument is shown in Fig 2, and it will be seen that the main conductor is of U shape, and passes under the movable coils. This conductor is made up of ropes of insulated copper wire, twisted together so as to form a cable with a hollow core. In order to correct any effect due to the induction of one arm of the coil upon the other the twisting is done in a very careful manner, so that the strands of the cable which are inside at the position marked *a*, are outside at the position *b*. The core of the cable is, as mentioned above, hollow, and brass tubes are passed up each arm of the U as far as the bend. The main object of these tubes is to prevent any deformation in the cable, but they also serve as a means of blowing air through to keep the conductor cool, if it should ever be necessary to use it for much heavier currents than those for which the instrument is primarily intended.

ON THE CAUSE OF THE CHANGES OF ELECTRO-MOTIVE FORCE IN SECONDARY BATTERIES.*

BY J. H. GLADSTONE, F.R.S., AND WALTER HIBBERT.

(Concluded from page 71.)

PART IV.—*Confirmations, Theoretical and Experimental.*

1. *Changes of E.M.F. with Two Similar Plates.*—In the discussion that followed one of our Papers at the Physical Society, Mr. Hibbert mentioned that if two lead plates are put into acids of different strengths, separated by a porous diaphragm, a voltaic current is produced on completing the circuit.† We have performed this experiment on two lead plates quantitatively, with reference to the E.M.F. produced, and have extended the observations to two peroxide plates.

The method of experimenting was as follows:—A divided cell was taken, in one compartment of which was placed sulphuric acid of about 0·2 per cent., in the other an acid varying from this strength upwards.

A pair of lead plates was tested in the weakest acid, in order to ascertain that when immersed in the same liquid they gave no appreciable E.M.F. One of the lead plates was then put into a stronger acid; and the E.M.F. between it and the other determined by the condenser method. This was continued up to a 98 per cent. acid, but, as the stronger acids act freely on spongy lead, the observations beyond 22·5 per cent. were made with two solid lead wires.

The results are given in the following table. The lead plate to the *weaker* acid behaved all through like a PbO_2 plate to the other, and it is, therefore, called the + plate.

Table VI.

Acid round + lead plate.	Acid round − lead plate.	E.M.F. in volts.
Per cent.	Per cent.	
0·2	0·65	0·036
"	1·35	0·047
"	2·85	0·060
"	5·5	0·066
"	10·5	0·082
"	14·5	0·094
"	18·0	0·102
"	22·5	0·109
"	36·5	0·150
"	48·0	0·164
"	57·5	0·204
"	85·5	0·247
"	98·0	0·266

A similar series of experiments was made with two peroxide plates. It is not likely, however, that the 99 per cent. acid had completely soaked into the meshes of the PbO_2. The peroxide in the *weaker* acid behaved like a lead plate, and is therefore called the − plate.

Table VII.

Acid round − PbO_2 plate.	Acid round + PbO_2 plate.	E.M.F. in volts.
Per cent.	Per cent.	
0·2	0·65	0·054
"	1·35	0·072
"	2·85	0·095
"	5·5	0·107
"	10·5	0·134
"	14·5	0·150
"	18·0	0·158
"	22·5	0·168
"	36·5	0·215
"	48·0	0·281
"	57·5	0·359
"	85·5	0·537
"	99·0	0·643

* Paper read before the Institution of Electrical Engineers on May 12th and 19th.

† *The Electrician*, Vol. XXVI., p. 154.

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The results are delineated in the following diagram :—

If we consider Curve I. in Fig. 7—which shows the E.M.F. between two *peroxide* plates, one of which stands in sulphuric acid of only 0·2 per cent., and the other in strengths varying from that to 99 per cent.—we see at once that, while it rises through 0·589 volt, it is far from being a straight line. It rises very rapidly at first, then bends over and remains convex till about 18 per cent. is reached, when it becomes somewhat concave till about 57 per cent., after which it is tolerably straight.

If we consider Curve II., Fig. 7—which shows the E.M.F. between two *lead* plates, one of which is in the weak and the other in stronger acids—we find that it follows a similar course ; but the ordinates are only about two-thirds as large up to about 30 per cent., after which they are relatively much less.

In Curve II., Fig. 2, we have an experiment in which the peroxide plate was placed in various strengths of acid, while the lead plate was retained in acid of uniform strength, namely, 14 per cent. The observations are only from 6·5 per cent. to 81 per cent., but on comparing it within those limits with Curve I , Fig. 7, it will be at once seen that the curves are identical in form. They are also identical in the absolute amount of the rise. The difference between 6·5 per cent. and 81 per cent. in Curve II., Fig. 2, is 0·404 volt ; whilst in Curve I , Fig. 7, the difference is 0·401 volt.

In Fig. 3 we have also observations on a cell with the PbO_2 plate in various strengths of acid from 43·5 to 88·5 per cent., while the Pb plate remains in acid of 27 per cent. On comparing

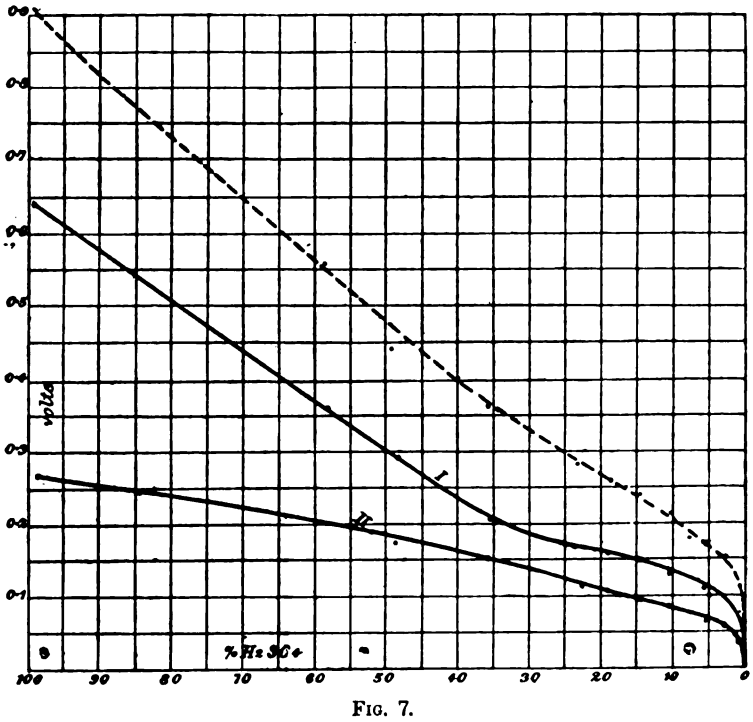

FIG. 7.

this with the similar portion of the curve in Curve I., Fig. 7, we find that in both instances we are dealing with a line which is very nearly straight. The rise of E.M.F. in Fig. 3 between the points mentioned is 0·307 volt, and in Fig. 7 it is 0·308 volt.

The close similarity both of the forms of the curves and the amount of the rise in each case shows that the causes of the phenomena represented in Figs. 2 and 3 are the same as those in Fig. 7, within the range of the experiments. There is, however, this essential difference in the experiments—that while in Figs. 2 and 3 we are dealing with a peroxide plate and a lead plate, in Fig. 7 we are dealing with two peroxide plates, and the results can be dependent only on the varying strength of acid. This, of course, is a strong confirmation of the theory we have propounded.

It is worthy of note that in the three experiments just compared together, the strength of the unchanged acid round the — plate was very far from being the same, varying, in fact, from 14 per cent. in Fig. 2, and 27 per cent. in Fig. 3 to 0·2 per cent. in Fig. 7. In other words, it does not matter what may be the starting point. This is just what might be expected if we are dealing merely with a differential result.

If we compare Curve I., Fig. 7, with the lower part of Fig. 3, we observe a general resemblance, but with well-marked differences. In each case there is the rapid rise at commencement, with the subsequent bend over and convexity. But in Fig. 3 the concavity has nearly disappeared. There is also another difference. The rise in this case between 6·5 per cent. and 49 per cent. is 0·251 volt, instead of 0·183 volt in Fig. 7.

These differences are easily explained. It will be remembered that the curve of Fig. 3 represents the variation of E.M.F. due to increasing strengths of sulphuric acid about the peroxide and the lead plate at the same time ; while Curve I., Fig. 7, represents the increasing E.M.F. due to increased strength of sulphuric acid solely at the $+PbO_2$ plate. In Curve II. of Fig. 7 we have, however, the E.M.F. due to increasing percentages of sulphuric acid round a – Pb plate. Now it has already been stated that increasing the sulphuric acid round the two plates acts in opposite directions in the two cases, so that the potential difference between them in any particular acid will be the arithmetic sum of the separate effects We have therefore added the two curves of Fig. 7 together and obtained the dotted curve, Fig. 7. It will at once be seen that this combined curve closely resembles the experimental curve in Fig. 3, the concavity having almost disappeared. The rise from 6·5 to 49 per cent. has become 0·27 volt, only slightly exceeding that of the curve in Fig. 3, namely, 0·25 volt.

We have thus resolved the rise and fall of E.M.F. during the charge and discharge of a cell into the two parts of which they are composed, and have determined them quantitatively.

2. *Confirmatory Evidence from Changes in Resistance.*—The general correctness of the conclusions arrived at in Part III. is supported, not merely by the known changes in E.M.F., but also by changes in resistance as given by Prof. Ayrton and his colleagues.

It is a matter of common knowledge that sulphuric acid varies very much in resistance according to its state of hydration ; that the resistance is least for acid of about 30 per cent., though not changing very widely between 15 and 50 per cent. ; and that if the acid become either weaker or stronger than these, its resistance rapidly increases. The following figures, calculated from Kohlrausch's results, will give an idea of the variation :—

Resistance of Sulphuric Acid Solutions.

% H_2SO_4.	Relative resistance.	% H_2SO_4.	Relative resistance.
2·5	6·73	50·0	1·35
15·0	1·33	71·0	3·79
30·0	1·00	95·0	7·29

Hence we should expect that if the acid against the working surfaces of the plates is being concentrated during charge, or greatly weakened during discharge, there would be a marked increase in resistance. This is exactly what is found to be the case. In the *Journal*, Vol. XIX., p. 590, is a diagram showing the very rapid increase of resistance during charge, the increase beginning when the E.M.F. (about 2·17) indicates, according to our theory, a strength of sulphuric acid against the working surfaces of the plates of somewhere about 50 per cent. : also showing that at the end of the charge "the resistance is five times as great as its minimum value."

This is particularly worthy of remark, because every other chemical change would tend to diminish, instead of increasing, resistance. The PbO_2 produced on the one plate, and the metallic lead produced on the other, are both much better conductors than the $PbSO_4$ which they replace.

On page 592 of the same volume is another diagram, showing that when the discharge of this cell was begun the E.M.F. had fallen from 2·30 to 2·06 volts ; and the resistance, which at the end of the charge was 0·0115 ohm, had fallen to 0·0038. We attribute both these falls to the same cause, namely, the reduction of the internal acid to about 30 per cent. Subsequently, the E.M.F. slowly diminished, while the resistance remained nearly the same for about five hours, when the E.M.F. more rapidly fell to 1·95 volts, and the resistance rose to 0·0055 ohm.

This is more than would be expected from the above table of resistances, but it must be remembered in this case that the other chemical changes—that is to say, the conversion of PbO_2 and Pb into $PbSO_4$ would also tend to increase, instead of diminishing, the resistance.

We do not lay great stress on precise numerical relations in the case of resistance, as the change in the strength of the acid at the working surfaces is only one of the factors, though an important one.

3. *Confirmation from Mr. Crompton's Experiments.*—During the discussion on the Papers by Prof. Ayrton and his colleagues, Mr. Crompton described two series of experiments which have a bearing on this subject.* In the first series some cells were discharged at rates varying from 11 to 66 amperes, and Mr. Crompton found that the ampere-hours delivered with a given range in potential difference fell from 300 to 125. He adds : In every

* *Jour.* Inst. Elec. Engineers, Vol. XIX., pp. 691, 692.

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case the "form of the curve is very definite, the turn-down as soon as the E.M.F. falls to 1·8 being very marked."

This follows naturally, because at the higher rate of discharge the absorption of the acid in the pores has become much quicker, while the diffusion is scarcely affected, so that the weakening process goes on much faster. The critical voltage of 1·8 simply indicates that the internal acid has become very weak. Mr. Crompton's curves and remarks show clearly that the fall is independent of the amount of PbO_2 remaining on the plate.

In the second series of experiments thicker plates were used, and then he found a greater diminution of delivering capacity at the higher rates of discharge—in fact, it fell from 300 to 90 ampere-hours, and at the highest rate the fall began almost at once. This must be the natural result of the greater distance through which the entering acid has to diffuse.

4. *Confirmation from Thermo-Chemistry.*—It is possible to test the matter further by applying Lord Kelvin's law as to the relation between the E.M.F. of a cell and the thermal value of the chemical actions contributing to it. We hope to go into this matter more fully, and shall content ourselves at present with pointing out that the liquid in a secondary cell is a mixture, or a chemical compound, of two different liquids—sulphuric acid (H_2SO_4) and water, in varying proportions.

The simple problem is to determine what would be the voltage of a PbO_2 – Pb cell in which there was nothing but pure H_2SO_4.

From the thermo-chemical data which are before us we arrive at the value 2·627 volts. Our own determination, by means of the closest approximation which we could make to absolute H_2SO_4, is 2·607 volts.

With pure water only in the cell, the calculated value is 1·35 volts, whilst in an experiment we found 1·36 volts.

In determining the thermo-chemical values for mixtures of these liquids it is necessary to subtract the heat of dilution from the available energy. On doing this, the calculated and experimental numbers do not agree so well as those already given, until we come to the most prominent part of the curve at about 6 per cent. acid. The theoretical value at this point, as determined from the known heats of combination and dilution, would give 1·901 volts, the experimental value being 1·89 volts.

With lower figures than six per cent. it is evident that the change is not to be accounted for on thermo-chemical grounds, unless we admit a change in the chemistry as we approach pure water— a conclusion already drawn from other data.

It is now easy to understand the large potential difference required for charging an accumulator. The current has to do extra work in concentrating H_2SO_4 at the PbO_2 plate, and the energy equivalent to that work must be obtained from an increased potential difference. For a dyad gramme equivalent of H_2SO_4 concentrated from a 10 per cent. solution to 100 per cent. about 17,000 calories will be needed, and this = 0·37 volt. The calculated charging E.M.F. must, therefore, be at least 2·3 volts.

Part V.—*Consideration of other Suggested Causes of the Variation of E.M.F.*

As other causes have been suggested for the changes in E.M.F., it is desirable to consider how far they are in accordance with the known facts of the case. It is evidently possible that the phenomena may be due to a number of causes co-operating.

1. It might be supposed that the reduction of the E.M.F. in discharge is determined by the relative amount of lead peroxide, which is destroyed or covered over with sulphate of lead.

This is absolutely disproved by the experiments of Prof. Ayrton and his colleagues, which are graphically represented in Figs. 1 and 2, given on p. 661, Vol. XIX. of the *Journal* of Electrical Engineers. It will there be seen, from the determinations of the percentage of PbO_2 found on plugs removed, that the formation of the PbO_2 in charging, and the decomposition of it in discharging, is a fairly regular and continuous action. It gives no indication of the rapid changes at the commencement and termination of charging and discharging; while during the intermediate period, when there is little change of the E.M.F. for many hours, the rate of variation in composition is steady. This is indicated, as far as the discharge is concerned, by the dotted line in our Fig. 4, which is reproduced from the Paper by Messrs. Ayrton, Lamb, Smith, and Woods. (See also remarks on Mr. Crompton's experiments, *ante*.)

2. Planté considered that the exceedingly high E.M.F. observed for the first few minutes on joining up a completely formed cell, immediately after its removal from the charging circuit, was due to the gaseous hydrogen found on the Pb plate. Gladstone and Tribe,* while considering that this was possible, drew attention rather to the hydrogen occluded by the lead as a possible cause, but stated at the same time that this occluded hydrogen was exceedingly small in quantity. Frankland showed by a totally different process that it was practically *nil*.

* "Chemistry of Secondary Batts.," p. 48.

But hydrogen on one plate and oxygen on the other would not, under the conditions, account for as much as two volts, and this explanation is therefore inadequate.

3. Planté observed that a small quantity of lead peroxide is formed on the Pb plate during discharge; and Gladstone and Tribe found in this a reason for the state of electric equilibrium being approached before the peroxide on the PbO_2 plate is exhausted, and also for the fact that partly discharged accumulators give an increased current after repose ("Chem. of Sec. Batts," pp. 27, 28). This last action is attributed to the extreme rapidity with which the lead peroxide formed on the Pb plate must be destroyed by local action.

Mr. Robertson has recently added to this the observation that the formation of peroxide of lead on the Pb plate does not take place till the E.M.F. has fallen much below the normal value.*

We have already attributed the resuscitation of the E.M.F. on repose to the inflow of the stronger acid to the acting surfaces of the opposed plates, but we must look upon this formation of peroxide of lead, where it does occur, as contributing both to the reduction of E.M.F., and its resuscitation.

4. *Presence of some Form of "Active Oxygen."*—It is well known that electrolysed sulphuric acid contains some hydrogen dioxide, which is probably due to the decomposition of persulphuric acid by water.

Gladstone and Tribe showed that the presence of hydrogen dioxide in a cell must reduce the peroxide of lead—an observation confirmed by Robertson (*Proc. Roy. Soc.*, vol. I., p. 107).

Last June, both Mr. Robertson and Prof. Armstrong communicated Papers to the Royal Society, in which they attach great weight to the presence of peroxides in the electrolyte, as causing a loss of efficiency. As only abstracts of these Papers are published as yet, we cannot enter into any criticisms of their experiments. Mr. Robertson, however, in a lecture to the Society of Arts (*Jour. S. A.*. XL., p. 44), states that the "variations in E M.F. appear to depend on which plate hydrogen dioxide is found at. When present at the peroxide plate it causes a rise, but when diffused through the acid and present at the lead plate, it causes a lowering of the E.M.F."

We therefore made several experiments with the addition of hydrogen dioxide (both ordinary, and carefully purified from hydrochloric acid). Our arrangements admitted of adding the hydrogen dioxide to the electrolyte surrounding either the peroxide or the lead plate. Some of the determinations of E.M.F. were made by a condenser, and others by observing the current through an astatic galvanometer in series with a high resistance.

We generally obtained a slight reduction (about 0·02 of a volt), but only what might be fairly attributed to the dilution of the sulphuric acid.

It was still possible that some other form of "active oxygen" might accomplish what hydrogen dioxide had failed to do; and in order to determine whether these peroxidised products of electrolysis have really a different effect at the cathode and anode, we completed the charging of a pair of plates in a divided cell filled with 20 per cent. acid, and found that the "peroxides," or "active oxygen," existed only round the PbO_2 plate. We then reversed the plates in the compartments, so that the Pb plate stood in the liquid containing the peroxides (H_2O_2, persulphuric acid, &c.). One minute after stopping the charging current, and immediately before the reversal of the plates in the cell, the E.M.F. was 2·185 volts. After the reversal of the plates the E.M.F. was measured by potentiometer at intervals, the results being given in the following table:—

Time after reversal of plates.	E.M.F. in volts.	Time after reversal of plates.	E.M.F. in volts.
Minutes.		Minutes.	
1	2·163	12	2·063
6	2·081	15	2·055
8	2·078	22	2·044
10	2·066	45	2·031

There was evidently here no unusual fall in the E.M.F. The figures are embodied in the dotted curve of Fig. 1, and on comparing it with the fall for 18·5 per cent. acid they will be found so similar as to show that peroxidised compounds round the Pb plate had no visible effect. In each case the voltage evidently fell very slowly to a uniform value, and that value agrees very fairly with what we find for a 20 per cent. acid in Fig. 3. Through the kindness of Dr. H. Marshall, we were able to test the effect of adding some persulphate of potassium to the sulphuric acid in a cell about the PbO_2 plate, but without visible effect on the E.M.F. As far, therefore, as our own experiments are concerned, the E.M.F. appears to depend on the acid strength of the electrolyte,

* Robertson's report to Prof. Ayrton, &c., *Jour.* Inst. Elec. Engineers, Vol. XIX., pp. 670-675.

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and not on the existence or the position of any peroxidised bodies dissolved in it.

ADDENDUM.

Although we did not undertake this investigation with the object of improving secondary batteries, there is one suggestion we should like to make—*i.e.*, the desirability of promoting diffusion as much as possible. We believe that this is becoming more and more the practice among those who make accumulators, and the previous considerations furnish three reasons for such a procedure.

It is well known that the accumulation of stronger acid at the lower part of a cell during its working is disadvantageous. This is believed to create differences of current density in different parts of the plate, and we have shown that it will also give rise to potential differences of fairly large value on each of the plates, and thus produce local action and the formation of lead sulphate. This inequality would be diminished if the diffusion of the acid could be promoted.

The fall of E M.F. at the close of discharge leaves a large fraction of the effective material not acted upon. This is mainly due to the weakness of the acid against the plates on account of the interstices being so much clogged ; and it would be counteracted to a considerable extent if the diffusion could be increased.

When a cell has been discharged at below 1·8 volts, there occurs the destructive action called "scaling." We are disposed to attribute this to abnormal chemical action arising from the very weak acid ; and if this be true, increased diffusion would in this case also act as a remedy.

Such increased diffusion might be obtained either by agitation or by heating, and we thought it interesting to try the effect of higher temperature on the output of our small cell. The following curve (Fig. 8) exhibits the result of one experiment :—

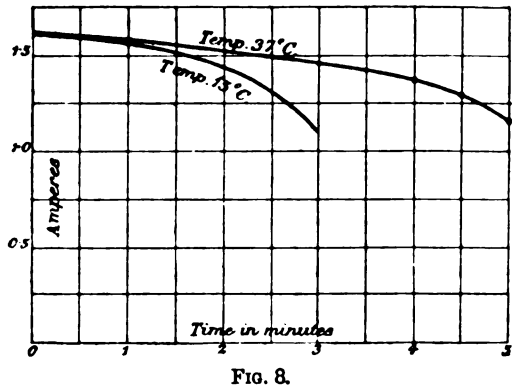

FIG. 8.

The discharge curves at the higher temperatures generally showed an output some 40 to 50 per cent. greater than those at the lower. But it is evident that the higher temperature would increase local action and the chemical action of the acid upon the spongy lead. This might be met by a reduction in the strength of acid, but we have not tested at what temperature and with what strength the advantage is at a maximum.

In addition to this suggestion, electricians will doubtless be able to make other useful applications of our conclusion that the changes of E.M.F. in a secondary battery depend on the strength of the acid that is against the working surfaces of the plates.

ELECTRICAL DISTRIBUTION BY THE NEWCASTLE-ON-TYNE ELECTRIC SUPPLY COMPANY.*

BY A. W. HEAVISIDE AND R. C. JACKSON, MEMBERS.

Preliminary.

The town of Newcastle is supplied with electrical energy by two companies, operating different districts, and distinct from one another. These are the Newcastle and District Company, using Parsons' turbines, supplying the southern and western portions of the town, and the Newcastle Electric Supply Company (the Company with which we are connected), supplying the northern and eastern portion. This Paper deals with the distribution of electrical energy by the Newcastle-upon-Tyne Electric Supply Company, Pandon Dene, it being thought that the members of the Institution would find interest in an account of the methods of working, and of the technical and financial results obtained during the first financial year of the Company's operations. The system employed is a high-pressure one of 2,000 volts, alternating current, with separate transformers in the consumers' premises. the price charged being 4½d. per Board of Trade unit. The Company was formed on January 7, 1889. Some questions having been raised upon legal points by the local authorities, the whole of 1889 was employed in negotiating the licence. These negotiations were more prolonged than usual, and it was not until the close of November that a provisional arrangement was entered into, enabling the Company to proceed with the street works in anticipation of the Board of Trade licence, which was not received until March 21, 1890.

Site.

Eligible sites for the establishment of a central station were found to be limited in number ; however, at Pandon Dene, some vacant land was eventually selected, which appeared to have some advantages in its favour. The business quarter is to the south, and the residential quarter to the north, thus facilitating the whole of the Company's operations being transacted from one point. The site is also alongside the sidings of the Blyth and Tyne branch of the North-Eastern Railway, which taps the Northumberland steam coal field. There is ample room for extension, as the Company's land occupies a space about 127ft. wide and 436ft. long, parallel with the railway. The absence of dwelling-houses in the immediate vicinity of the works avoids difficulties which might arise from the vibration caused by machinery in motion. Against these advantages must be set the want of cheap water for condensing purposes. The company's water is taken from the intermediate service of the local water company, the average cost per 1,000 gallons being 9·78 pence.

Buildings.

The dominant idea in laying out the station buildings was to so arrange them as to reduce any reconstruction to a minimum ; the erection of each successive section being carried out without interruption or disturbance to the plant already fixed. At the present time two sections have been built, enclosing a space 119ft. by 74ft. by 13½ft. high to the top of the girders. This space is covered by means of a light iron lantern roof, supported upon wrought-iron girders and cast-iron pillars, resting on concrete footings. The openings between the pillars are filled up with common brick, lined on the inside of the engine and dynamo-room, to about 7ft. 6in. high, with varnished pitch-pine. A brickwork partition separates the boiler-house, which is 74ft. long by 55ft. wide, from the engine and dynamo-room, 74ft. by 63ft. 6in. Two chimney-stacks have been built, one at either end of the main boiler flue, which runs along the boiler-house side of the partition wall. One chimney has a sectional area at the top of 30 sq. ft., and is 85ft. high ; the other chimney measures 23·5 sq. ft. at the top, and is 110ft. high. Great care had to be taken with the foundations, as the natural bed is no less than 75ft. below the present ground level, the intervening soil being made ground.

Contents of Buildings.

The station at present contains plant capable of a total output of 600 kilowatts, in the following units :—

1 250-kilowatt alternator ;
3 100-kilowatt alternators ;
1 50-kilowatt alternator ;

each machine being rope-driven by means of a separate engine. The year's operations dealt with in this Paper were, however, carried out by

3 100-kilowatt alternators, and
1 37½-kilowatt alternator.

The machinery in the station consists of :—

Three double-flued Lancashire boilers, manufactured by Messrs. Robey and Co., Lincoln.

General Particulars.

Working pressure, 120lbs. per square inch ; all plates of the best Siemens-Martin mild steel ; diameter of shell, 7ft. ; length of boiler, 28ft. ; boiler shell plates, $\frac{9}{16}$in. thick ; flue plates, $\frac{5}{8}$in. thick ; end plates, $\frac{3}{4}$in. thick ; number of flues, two ; diameter of flues, 2ft. 9in. ; 12 Galloway tubes ; heating surface, 750 sq. ft. ; grate area, 38 sq. ft. Two of these boilers have been fitted with Messrs. Bennis' mechanical stokers, and one of them with Messrs. Jas. Proctor's stoker. The figures of a test with these stokers will be given later in the Paper. N.B.—Two additional boilers have been fixed for the extensions now proceeding, fitted with Proctor's stokers.

Engines and Dynamos.

1 vertical compound engine by Robey and Co.

General Particulars.

Cylinders, 11in. and 18in. diameter, by 12in. stroke ; speed, 200 revolutions per minute ; fly-wheel, 6ft. diameter, grooved for eight 1in. ropes ; power, economical load, 75 I.H.P., with 110lb. steam pressure at the engine stop-valve. The engine is fitted with automatic expansion gear, and with Mever's adjustable cut-off on the L.P. cylinder. This engine drives a 37½-kilowatt Mordey-Victoria alternator with an E.M.F. of 2,000 volts effective at a speed of 650 revolutions per minute.

* A Paper read before the Institution of Electrical Engineers on May 26, 1892.

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3 compound horizontal fixed engines by Messrs. Robey and Co.

General Particulars.

Cylinders, 16in. and 26½in. diameter, by 36in. stroke, fitted with the Rowland Richardson trip valve gear; 73 revolutions per minute; fly-wheel, 15ft. diameter, grooved for twelve 1¼in. ropes; weight of fly-wheel, 5 tons. N.B.—The fly-wheels are being weighted with an additional 5 tons each. Power, economical load, 175 I.H.P.; maximum working load, 240 I.H.P., with 110lb. pressure of steam on the engine side of the stop-valve.

These engines each drive a 100-kilowatt Mordey-Victoria alternator at a speed of 430 revolutions per minute. Each alternator is excited independently by means of an exciter connected direct to the alternator shafts. Another engine of the same class has lately been erected for the purpose of driving a 250-kilowatt Mordey-Victoria alternator.

General Particulars.

Cylinders, 19½in. and 33in. diameter, by 40in. stroke; speed, 70 revolutions per minute; fly-wheel, 17ft. diameter, grooved for 13 1¼in. ropes; weight of fly-wheel, 15 tons. Power, economical load, 400 I.H.P.; maximum load, 500 I.H.P.; with 110lb. of steam on the engine side of the stop-valve.

Water-Feed Apparatus.

One Gloster Duplex Pump, to throw 800 gallons per hour. Two Holden and Brooke's Exhaust Injectors, fitted with auxiliary live-steam nozzles, each delivering 600 gallons per hour at about 170°F. One additional injector, as above, for the plant extensions now going on.

Switch-Board.

Several forms of high-tension switches have been tried, but none have been found quite satisfactory. A permanent switch-board is now being designed to suit the Company's requirements.

Use of Plant.

For the light day and night load, the high-speed vertical engine is employed, the other machinery being brought into use as the service requires. The circuits, four in number, are coupled together or separated, as the load varies.

Distribution.

The electrical energy is distributed by means of four main circuits of concentric cable, insulated with vulcanised rubber, drawn into cast-iron pipes, of which nearly 10 miles have now been laid. The system adopted is that of one pipe, one cable, and means are provided at the street boxes by which the service may be treated either as a radial one or as a network, without disturbance to the insulation.

Cables.

The inner and outer conductors of the concentric cables are separated at each junction or lead-in, and are terminated by means of metallic washers, which are screwed down and clamped together on porcelain insulators. The system of mains is thus quite flexible, and changes in connections are made as easily and expeditiously as at a Post Office test box.

Street Boxes.

The street boxes are built of brick, set in cement, and protected from surface leakage by double cast-iron covers.

Transformers.

The transformers employed are, in general, those of the Elwell-Parker design, varying in capacity from 1 to 10 E.H.P., and are usually placed in cellars, upon the premises of the individual consumers. The Mordey, Kapp, Swinburne, and Tyne transformers are being experimented with.

Meters.

The "Shallenberger" is in general use, with some Aron, Ferranti, Thomson-Houston, and Frager meters under trial.

Working Results.

As already stated, the Company did not commence the supply of electrical energy until 1890, and then only experimentally. It was simply a year of construction and organisation. Commencing from January 1, 1891, by the end of the year the lamps installed equalled 431,000 watts, rising from 253,000 at the beginning of the year, or a mean of 342,000 watts. During the year 244,470 units were metered at the consumers' premises. The units metered at the station amounted to 327,821, showing a loss from all causes in distribution of 25·4 per cent. Dividing the total watt-hours sold during the year by the mean capacity in watts installed, we get a result of $\frac{244,470 \times 1,000}{342,000} = 714$ as the average lighting hours per annum. That is to say, our annual output was equivalent to running all the lamps installed for 714 hours—practically, two hours per day per lamp.

Character and Class of the Installations.

With the exception of the Post Office and the Public Library, the installations are small rather than large, there being no hotels and few restaurants, but mainly shops, offices, and private houses; the net result being a low load factor of 8·16 per cent. By the term "load factor" we mean the ratio of the units sold to the units that could be sold if all the lamps were always on.

Thus, $$\frac{\text{Metered watt-hours} \times 100}{\text{Mean watts installed} \times \text{number of hours in the year}}$$

$$= \frac{244,470 \times 1,000 \times 100}{342,000 \times 8,760} = 8{\cdot}16 \text{ per cent.}$$

Price.

The price charged by the Company has been described as the "phenomenally low one of 4½d per B.T.U." (less 5 per cent. discount). With gas costing only 1s. 10d. (less 10 per cent. discount) per 1,000 cubic feet, it is quite evident that whatever advantages the electric light possesses over gas, it would be difficult to obtain a higher price than 4½d. Believing that at this price a profit could be earned, we recommended the Company to charge this low figure, and we may say that our anticipations have been realised. The problem was, therefore, how to produce the unit at a low cost, and to obtain custom in sufficient amount to earn a fair dividend upon capital invested.

N.B.—It may be objected that the period of work upon which this statement is made is too limited to inspire confidence; but we venture to think that, once having overtaken our establishment charges, the commercial prospect will improve rather than the reverse.

Cost of Production: Coal.

The Company uses small steam coal, supplied and delivered by the Gosforth and West Moor Coal Company at the average price, over the year, of 5s. 10d. per ton.

Since 2,300 tons of coal were used, the quantity of coal burnt per unit sold amounted to $\frac{2,300 \times 2,240}{244,470} = 21{\cdot}074$lbs., at a cost of 0·663 of a penny.

It is to be noted that this coal bill includes all consumption for trial runs of new plant, various testing work, banking and making up of fires, steam heating to offices, and for all other purposes.

We consider that it would be interesting and of value if a relation could be established between the result as given above and the results—

1. If a standard Welsh coal had been used;
2. With water-tube boilers, burning small steam coal, with mechanical stokers;
3. With water-tube boilers, burning Welsh coal, both 2 and 3 being worked under the same conditions with respect to the load factor as in our own case.

For the purpose of facilitating such a comparison, we give analyses of Welsh coal and of that used by us—

——	Welsh coal.	Gosforth and West Moor.
Carbon	$14{\cdot}500 \times 0{\cdot}84$	$14{\cdot}500 \times 0{\cdot}649$
Hydrogen	$62{\cdot}032 \times (0{\cdot}046 - \frac{0{\cdot}06}{8})$	$62{\cdot}032 \times (0{\cdot}053 - \frac{0{\cdot}06}{8})$
Sulphur	$4{\cdot}032 \times 0{\cdot}015$	$4{\cdot}032 \times 0{\cdot}0124$
Ash, per cent.	4·9	13·44
Heat units	14,833	11,300
Theoretical evaporative efficiency in pounds of water from and at 212° Fahr., deducting ash in both cases	15·45	11·75
Or including ash	14·69	10·17

as the theoretical value per pound of coal, showing a difference in favour of Welsh coal of 31 per cent. It may here be remarked that the difference in cost between the best Newcastle coal and that used by us is generally about 50 per cent.

It is quite evident from the foregoing analyses that, in order to compare our results as to weight of coal per unit sold with London figures, a fair-sized divisor would be required. Our want of sufficient data does not enable us, unfortunately, to state what that divisor ought to be. We are in hopes of being enlightened on that point during the discussion on the Paper.

Water Account.

All the water consumed at the station for all purposes was measured by a Kennedy water meter, which registered 2,922,000 gallons for the year. To arrive at the amount of the water evaporated, a deduction of 10 per cent. is made to allow for such items as washing out and filling up of boilers, cleaning down lavatories, buildings, &c. The allowance being made, we have, as the total

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water evaporated to steam, 2,629,800 gallons, or a water consumption per unit sold of $\frac{2,629,800 \times 10}{244,470} = 107{\cdot}5$ pounds, at a cost of 0·1053 of a penny per unit generated, or at the station = $107{\cdot}5 \times 0{\cdot}75 = 80{\cdot}63$ pounds.

The average evaporation of the boilers thus becomes—

$$\frac{\text{Pounds of water per unit sold}}{\text{Pounds of coal per unit sold}} = \frac{107{\cdot}5}{21{\cdot}074} = 5{\cdot}1\text{lb.}$$

We have obtained an evaporation of from seven to eight pounds of water per pound of coal with the boilers working under the best conditions; the difference, $7{\cdot}5 - 5{\cdot}1 = 2{\cdot}4$lb., is accounted for principally by banking of fires at times of low load and heating up of standing engines.

Oil.

Oil averaged 0·0014 gallon at a cost of 0·044 of a penny per unit sold.

Waste, Sweat Cloths, and Sundry Stores.

These work out at 0·055 of a penny per unit sold.

Repairs.

Repairs to buildings and plant at the station amount to 0 2480 of a penny per unit sold. This sum includes everything necessary to maintain the machinery at its full efficiency, and also to carry out some small alterations that experience suggested for the improvement of the plant.

Labour and Supervision.

It is found that at the period of maximum load the staff necessary to run three 200 H.P. engines and three 100-unit alternators consists of one station assistant, one engine-driver, and one stoker. Three sets of men are employed, arranged in shifts of eight hours each, with one hour overlap for cleaning, oiling, &c. The cost of the service, inclusive of proportions of the manager's and secretary's office charges, works out at 1·9462 pence per unit sold. The cost of all service external to the station over nearly 10 miles of mains, leads-in, transformers, meters, &c., is 0·2817 of a penny. To these figures have to be added the general charges, which amount to 0·6807 of a penny.

Summarising the cost, we have—

	d.	d.
Coal	0·663	
Oil	0·0440	
Petties	0·0579	
Water	0·117	: 0·8819
Repairs	0·2480	
Labour and supervision	0·8163	
External	0·2817	
General (rent, rates, taxes, law, sundry expenses)	0·6807	: 2·0267
		2·9086 per unit sold.

Capital.

When the capital account is closed for the works in progress, it is estimated that for each kilowatt installed an expenditure of £50 will have been incurred. This result will in all probability be reached by the end of the present year, when the plant erected will be capable of working at 600 kilowatts, or of dealing with 800 kilowatts wired, leaving one-fifth reserve plant.

Plant Efficiency.

We shall now consider some of the points in connection with the plant efficiency, it being always borne in mind that the results actually obtained are over a period of twelve months, with a mean load factor of 8·16 per cent.

Boilers.

With a view to the economising of labour, and to abate the smoke nuisance as far as possible, the boilers were fitted with mechanical stokers, as already stated. The following is a table showing the result of a test between the two classes of stokers now in use :—

Stoker Tests, July 5 and 18, 1891.

Description of firing.	Time in hours.	Gallons of water evaporated.	Coal consumed in pounds.	Pounds of water per pound of coal.	Per pound of combustible. From, and at 212 F.
Bennis stoker and bars	3¼	1,750	2,492	7·02	8·29
Proctor „ „	3¼	1,920	2,352	8·16	9·64
	—	9·7 %	6 %	16·2%	In favour of Proctor's stoker.

We have found the boilers supplied to us to be each capable of generating steam for 240 I.H.P. at the engine cylinders without undue forcing. The boilers are generally fed through exhaust steam injectors, assisted by auxiliary live-steam jets, the average temperature of the feed water being about 170°F.

Water.

The water used is of a medium quality, having 15 degrees of hardness.

Engines.

The engines are fitted with steam jackets in both the high-pressure and low-pressure cylinder. The steam, on its way to the low-pressure cylinder, passes through an intermediate receiver, where its temperature is raised, and probably some of the contained water re-evaporated to steam, by means of a coil of piping, through which a passage of live steam is maintained.

Dynamos.

The Directors have been much pleased with the satisfactory reports which have come in from the consumers regarding the steadiness of the light, which is in part due to the good government of the engines, and to the incidental advantage that the Mordey-Victoria alternators possess in the momentum acquired by the revolving field magnet. Improvements are being introduced as suggested by experience, and the 250-unit alternator now in course of erection is fitted with an outer bearing. The mechanical construction of the armatures also improves with each succeeding make. The oiling arrangements, by means of small pumps driven from the alternator shafts, have proved very effective.

Station Output and Efficiency.

The E.M.F. of the dynamos is measured by Cardew voltmeters, and the current by means of Evershed ammeters, the readings being taken every half-hour and posted in the engine-room day-book. The correctness of the various ammeters is checked from time to time by comparison with a Siemens dynamometer, which is, again, checked in the laboratory of the local College of Science. The principal data are as follows :—

Units metered at the consumers'	244,470
Station units	327,821
Loss in distribution	25·4 pr. cnt.
Total running hours at the station	7,504
I.H.P. hours	939,500
Average I.H.P. per hour $\frac{939,500}{7,504}$	= 125·2
Units per running hour (at the station) $\frac{327,821}{7,504}$	= 43·686
Average watts per I.H.P. per hour $\frac{43,686}{125·2}$	= 348
Weight of water per I.H.P. per hour, inclusive of radiation and condensation losses $\frac{2,629,800 \times 10}{939,500}$	= 27·91lb.
Average commercial efficiency of engines and dynamos $\frac{\text{Total E.H.P. for the year}}{\text{Total I.H.P. for the year}} \times 100$	= 46·6 per cent.

Parallel Working.

Trials have been made to work in parallel, with only a partial success. The trials called attention to the varying angular velocity of the engine fly-wheels, due to the early and quick cut-off of the trip valve gear. We hope to obtain successful results by increasing the weight of the fly-wheels, which work is now in progress; also by increasing the elasticity of the drive by the use of spring pulleys arranged on the principle of the transmission dynamometer, in place of the ordinary pulley. As a uniform turning effort is the end to be aimed at, we believe that the steps we are taking will accomplish that result.

Distribution.

The installations on the consumers' premises amounted to 431,000 watts on December 31st, 1891. The nominal transformer capacity supplying the above was 391,000 watts, or an excess of installed watt capacity to transformer provision of 9 per cent. The percentage of excess has been reduced by the recent extension of small shop-lighting, &c.; it had previously been run up to as high as 25 per cent.

The object we had in doing this was to keep the average transformer efficiency as high as possible, and at the same time to avoid undue fall of pressure in the service. This course may be safely carried out, if we discriminate between those consumers who burn all their lamps simultaneously and those who never by any chance do so. The average proportion of lamps lighted at any one time, to lamps installed, is about 45 per cent. Taking an extreme case, we have a proportion of 28 per cent. excess. We find the average lighting hours per annum of the various classes of consumers on the Company's mains to be as follows :—

Restaurants.	Shops.	Offices.	Private Houses.
1,563	459	499	344

As previously stated, the distribution losses from all causes average 25·4 per cent. over the year. The loss is incurred from

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two sources—transformer and line losses. Weekly observations are taken, by means of Lord Kelvin's milliampere meter and a low-reading Siemens dynamometer, for the purpose of checking and comparing these losses.

Summary.

Summarised, the chief results embodied in this Paper are—

1. Load factor (as per definition)	8·16	per cent.
2. Loss in distribution	25·4	,,
3. Average lighting hours per annum	714	
4. Coal bill per unit sold	21·074	lb.
5. Water = 107·5 + 10 per cent. for water deducted for efficiency results	118·2	
6. Pounds of water evaporated per pound of coal, banking, &c., inclusive	5.11	lb.
7. Water consumption per I.H.P. hour	27·91	lb.
8. Engine and dynamo average efficiency	46·6	per cent.

General Conclusions.

Much discussion has taken place on the merits of the various methods of supply. We have had to consider the matter from a purely commercial point of view, having regard only to giving an efficient service, at the least cost, and quite without prejudice in favour of any particular system or mode of working.

That the results have been obtained by the use of separate transformers in the consumers' premises, without a secondary network, by machinery constantly running, with no storage except the coal heap, gives some ground for believing that in alternating-current distribution there exists a means of supplying the public with electric energy, and of meeting Parliamentary and other obligations, at a price which is satisfactory to the public, and affords investors a reasonable interest on their capital.

It may be stated to those interested in sub-transformer station distribution that the average losses in direct distribution over this year have been reduced from 25·4 per cent. to 19·5 per cent., and as the load increases it is hoped that further reductions will take place.

THE COUNTER ELECTROMOTIVE FORCE OF THE VOLTAIC ARC.*

BY F. STENGER.

The electrical phenomena of the voltaic arc have been the object of many investigations. The great difference of potential between the two electrodes, and the extreme constancy of this pressure in face of variations in the length of the arc, have led people to suppose that a counter electromotive force existed in the voltaic arc.

The researches on this subject have been carried by direct and indirect methods. The indirect methods, such as those of Von Larrgs, Arons, &c., are open to criticism, because they involve Ohm's law, and it is not admissible for one moment that the resistance of the gaseous column which composes the arc is independent of the current. The oldest of the direct methods was that of Edlund, who broke the main circuit, and about $\frac{1}{80}$th of a second later closed the circuit of the carbons through a galvanometer. Edlund obtained a deflection, which he attributed to the supposed counter E.M.F. Later on, Luggin employed an analogous method, which after laborious investigations yielded him a negative result, although the time which elapsed between the rupture of the arc and the closing of the shunt circuit was less than in Edlund's experiments. According to my own experiments Edlund's results were incorrect.

An objection may be made against Luggin's method, that if the condition of polarisation disappeared in less time than it took to close the derived circuit, Luggin's experiments demonstrated nothing. Lecher reinvestigated the matter, using another method.

In Fig. 1 D is dynamo connected to the carbons through the galvanometer G. The galvanometer needle was deflected against a stop by the dynamo current, but it could deflect freely in the opposite direction. The galvanometer, being in the main circuit, had to have a short thick wire winding. By joining the points *a* and *b* by a metallic conductor the dynamo was short-circuited, the difference of potential between the carbons became zero, and the arc was extinguished. If a counter E.M.F. existed in the arc, the galvanometer would have given a deflection. The result being negative, Lecher concluded that no counter E.M.F. existed.

This method was a decided advance on that of Edlund and of Luggin. The time which elapsed between the extinction of the arc and the making of the shunt circuit was zero, or excessively small. It may, however, be objected that the method is not very sensitive, since it requires a low-resistance galvanometer, and the resistance of the dying arc may be very high. My method only differs from that of Lecher by a detail which shows that the sensitiveness of the arrangement is amply sufficient.

Fig. 2 gives an idea of the arrangement. D was a flat-ring shunt-wound Schuckert machine, A a Kohlrausch galvanometer by which the normal current was measured, T a tangent galvanometer with the stop device mentioned before, R an additional resistance, B a battery of five accumulators, the negative pole of which was connected to the positive carbon. Two conductors connected the points *a* and *b* to a commutator.

While the lamp was at work the accumulators were being charged. The tangent galvanometer gave no deflection, its needle being jammed against the stop. By a turn of the commutator the dynamo was short-circuited, and being a shunt-machine the current

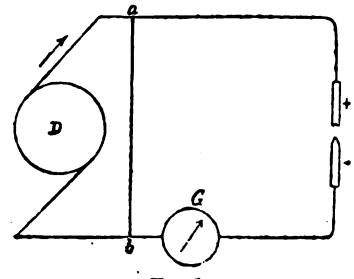

Fig. 1.

became zero. The difference of potential at the terminals of the lamp, therefore, fell very rapidly, and the arc disappeared. At the same instant the galvanometer gave a large deflection, sometimes exceeding 90deg. This experiment showed that the gaseous column continued to conduct, for a very short space of time, it is true, but sufficiently long to enable the current to effect a by no means sensitive galvanometer. The experiment did not, however, determine whether the deflection was due to the E.M.F. in question, or to the accumulators.

The accumulators were therefore removed, and the experiment repeated. The galvanometer did not then, on the short circuit being completed, deflect more than 0·5deg. to 1deg., a small deflection due to the spring of the stop.

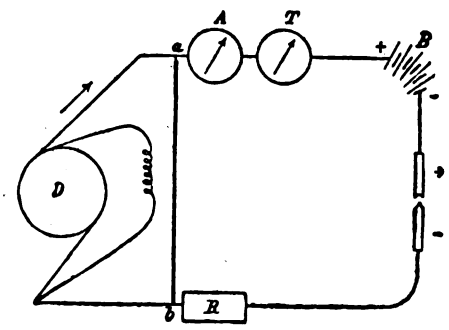

Fig. 2.

The following table gives a few of the observations. The experiments were only made when the arc was steady. The current and the difference of potential were observed immediately before the interruption of the main circuit; the length of the arc was estimated approximately.

Five Accumulators in Series.

Current.	Volts.	Length of arc (mm.).	Deflections.
17	40	3	55deg.
16	40	2	55 ,,
14·5	40	1	20 ,,
15	40	1	30 ,,
15	43	3	11 ,,
15	41	1	54 ,,
15	38	0·5	112 ,,
16	35	0·5	127 ,,

As would be predicated, the largest deflections corresponded to small arcs and large current. Deflections were also obtained when a certain time was allowed to elapse, and the temperature of the arc had become normal.

Thus, while at the moment of extinction of the arc the accumulators sent a large current through the gaseous column left by the arc, no discharge at all was obtained without the accumulators. It seems, therefore, to be proved in a definite manner that no counter E.M.F. exists in the arc.

* *Wied. Ann.*, 1892, No. 1, p. 33.

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THE ELECTRIC RAILWAY SCHEMES IN PARLIAMENT.

JOINT COMMITTEE OF LORDS AND COMMONS.

Another meeting of the Lords and Commons Joint Committee on the Electric and Cable Railway Bills for the Metropolis was held on Thursday, last week: Mr. Stansfeld in the chair.

Mr. DONALD MACMILLAN, of the firm of Messrs. Fowler and Co., solicitors, gave evidence as to the provisions in these Bills and in former Acts respecting the appropriation and use for tunneling of the subsoil beneath the roads and footways. There was nothing to prevent any owner who could establish damage claiming compensation.

Sir BENJAMIN BAKER and Sir JOHN FOWLER gave evidence as to the practicability of the undertakings from an engineering point of view; and explained that now that the efficiency of electric motors and cable traction had been demonstrated, one of the great difficulties which prior to 1884 had stood in the way of promoters had been removed; another difficulty being the want of sympathetic co-operation on the part of public authorities and the loading of the Bills with onerous clauses, which made the undertakings financially impossible.

Mr. BEACHCROFT was heard as to the desire of the London County Council that the proposed lines should be carried further into the outskirts so as to facilitate the transfer of the population from the congested districts of the metropolis.

The Committee adjourned until Monday, when they presented the following Report to the Houses of Parliament.

REPORT.

1. The Committee have met and have considered the matters referred to them, and have taken evidence submitted to them by the promoters of the various schemes including that of electric and other engineers, as well as that of representatives of the London County Council, of the Corporation of the City of London, of the agent and surveyor of Lord Portman's St. Marylebone estate, and of the Board of Trade.

2. The railway schemes that have been referred for their consideration are the following, viz.:—

The Great Northern and City Railway,
The Central London Railway,
The City and South London Railway,
The Waterloo and City Railway,
The Baker-street and Waterloo Railway, and
The Hampstead, St. Pancras, and Charing Cross Railways.

3. The Committee desire, in their report, to deal separately with the proposed Great Northern and City Railway.

4. The main objects of this scheme would appear to be to assist and relieve the great and growing local passenger traffic of the Great Northern line, and to afford it a new and direct access to the City.

5. It appears to the Committee that there can be no reason why this scheme should not be considered by Committees in ordinary course.

6. Further, the Committee are convinced that direct communication through London for the Main Railway lines north and south of the Thames, whether for the convenience of their country or their suburban passenger traffic, would be of undeniable utility. And they cannot doubt that the growing needs of those lines will, sooner or later, lead to the construction of one or more of such communications.

7. But the purposes which the proposed new lines, with the exception of the Great Northern and City Railway, appear intended and adapted to meet are of a different character.

8. They are required to relieve the overgrown passenger traffic along the chief thoroughfares, to provide for the natural expansion of London, and to check the congestion of our metropolitan population by facilitating cheap communication outwards to a circumference which tends constantly to recede.

9. More such lines of communication are required with existing suburbs; and there is growing need of their extension still further into the country, in order to meet the increasing necessity for the removal of portions of the population to a greater distance.

10. The lines now in question will afford some portion of this much-needed accommodation; and where they terminate in or near the open country they are practically certain of further extension to meet the needs of a growing and spreading population.

11. It does not appear to the Committee, with regard to any of these lines, that their construction would prevent that of other lines which the necessities of London may from time to time require, and they see no reason, therefore, for advising the postponement of the consideration, in ordinary course, of any of these Bills.

12. With regard to the question whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and future probable traffic, the Committee report that the evidence submitted to them was conclusively in favour of the sufficiency and the special adaptability of electricity as a motive power for the proposed underground tubular railways, whilst the method of cable traction appears also to be of recognised utility, especially in the case of steep gradient lines.

13. The proposed routes appear to be fairly satisfactory, considered as an instalment of the more complete accommodation necessary to meet the constantly increasing needs of London.

14. As to the terms and conditions under which the subsoil should be appropriated, the Committee report that in the case of private property, not under the public streets, it appears to them to be desirable that the companies should be allowed to acquire a wayleave, instead of purchasing the freehold of the land, subject to the terms of the Lands Clauses Acts as to compensation.

15. In the case of public streets the Committee think it expedient that the companies should be empowered to pass under the streets at sufficient depth without payment of compensation for the wayleave. In consideration of such free passage the Committee advise that the companies should be put under obligation to furnish an adequate number of cheap and convenient trains.

16. The evidence submitted to the Committee on the question of the diameter of the underground tubes containing the railways, has been distinctly in favour of a minimum diameter of 11ft. 6in.

17. The Committee have directed the minutes of evidence taken before them, together with an appendix, to be reported.

PARLIAMENTARY INTELLIGENCE.

The London County Council (Subways) Bill.

In the Select Committee of the House of Lords engaged in considering the provisions of the London County Council (Subways) Bill on Wednesday, clause 11, which deals with the regulation of water, gas, and electric wire mains carried through the subway, was under consideration. Six electric lighting companies petitioned against the Bill, objecting to have their wires subject to the control of the County Council instead of the Board of Trade, and claiming to remain, as hitherto, under the general order of 1869. The Earl of Crawford was examined in support of the petitioners' case, and stated that he was concerned in the investigation which resulted in the subdivision of London into districts for the purposes of electric lighting, and in the inquiry held by the Board of Trade in 1888. It was at the time thought that it would be best to carry the electric lighting wires in subways. There were then only four subways in existence, one of which was the Southwark subway. The objection to having the mains for electric lighting and gas and water in one chamber was the danger of flooding and of explosion from fire when the pipes were under repair. It would, in his opinion, be desirable that the Board of Trade should have control of the mains in the subway and not the County Council. Sir F. Bramwell, adviser to the electric lighting companies, also gave evidence in support of the objections of the petitioners.

The Committee decided that the petitioners had proved their case, and that they should be exempted from the provisions of the Bill, with the exception that if Clause 11 were so altered that the Board of Trade should be the controlling authority then the electric lighting companies should not be exempt.

LEGAL INTELLIGENCE.

Western Counties and South Wales Telephone Company (Limited) v. Bournemouth and District Electric Supply Company (Limited).

In the Chancery Division, on Friday, the case of the Western Counties and South Wales Telephone Company v. Bournemouth and District Electric Supply Company again came before Mr. Justice Chitty. This was a motion which asked that a writ of sequestration might be issued for contempt of Court against the Bournemouth and District Electric Supply Company for wilfully disobeying an order of the Court directing that they should be perpetually restrained from working or using their electric lighting system, apparatus, and works in the town and neighbourhood of Bournemouth, in such a manner as to injure or interfere with the plaintiff's exchange system. Mr. Byrne, Q.C., who appeared for the defendants, asked for further time to consider the fresh affidavits which had been filed. His Lordship granted the application.

Pepperell v. City and South London Railway Company.

The plaintiff in this action, which came before Mr. Justice Wills on Tuesday last, was a traveller, and he sued the defendant railway company to recover damages for personal injuries. His case was that on July 22nd he was about to travel from Kennington Station to Stockwell, and went to Kennington Station. He had never travelled by the electric railway before, and complained that the platform was so badly lighted that he could not see the permanent way. As a consequence he fell on to the line, and severely bruised and injured himself. He also complained that there were no porters on the platform to assist passengers. The defence was that the station was sufficiently lighted, and that the accident happened solely through the negligence of the plaintiff. The plaintiff appeared in person, and Mr. W. Graham appeared for the defendants His Lordship gave judgment for the defendants, with costs.

BOOKS, &c., RECEIVED.

"Report to the Governors." April, 1892. City and Guilds of London Institute.

"A Treatise on Electricity and Magnetism." By James Clerk Maxwell. Vols. I. and II. Third edition. (Oxford: Clarendon Press.) Price £1 12s.

"Technology Quarterly." Vol. IV. No. 4. (Boston: Massachusetts Institute of Technology.)

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TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Corporation of Hanley invite tenders for the execution of works required for the supply of electricity within the borough, in accordance with the Hanley Electric Lighting Order, 1891. Plans and particulars may be obtained from Mr. Joseph Lobley, borough engineer; and tenders must reach Mr. Arthur Challinor, town clerk, before noon on Monday, June 20. Further particulars appear in our advertisement columns.

——The Corporation of Hull require tenders for supplying and erecting a switch and distributing board. Tenders are to be in by Thursday, June 17th. Further particulars will be found in our advertisement columns.

—— Tenders are invited for the supply to the General Post Office of red fir telegraph poles, and for creosoting them. Forms of tender can be obtained from Mr. Charles E. Stuart, Controller of Stores, Telegraph-street, E.C., to whom tenders must be sent by noon on June 24th. Further particulars appear in our advertisement columns.

—— The Great Western Railway Company invite tenders for the purchase of old telegraph materials, consisting of gutta-percha wire, copper battery mud and silver battery plates. Forms of tender may be obtained of the Secretary at Paddington Station, or of the Storekeeper at Swindon; and tenders must reach Mr. G. K. Mills, the Assistant Secretary, Paddington Station, by Wednesday next, the 1st prox.

—— Tenders are invited for the electric lighting of the Rue de la Station, the Place de la Station, the Grand Place, and the theatre in Louvain, Belgium. Tenders must reach the Hotel de Ville, Louvain, by July 1st.

PLANT FOR SALE.—Messrs. Wheatley Kirk, Price and Goulty announce in our advertisement columns that they have for sale a 10-arc light installation, comprising two 30-light Thomson-Houston continuous-current dynamos, a 100-H.P. Babcock-Wilcox boiler, 58 Thomson-Houston double carbon arc lamps, a 12in. Marshall vertical steam engine, &c.

—— Our advertisement columns contain an announcement of some electric plant for sale, comprising a 400-light compound and a 100-light shunt excelsior dynamo, a 5 H.P. motor, and 51 E.P.S. cells. Further particulars of "Electric," care of Eason and Son (Limited), Dublin.

APPOINTMENT VACANT.—An engine driver, to attend to the electric light installation, is wanted at once, at the Smallpox Hospital Ships, Long Reach, near Dartford, Kent. The wages are 25s. per week, with board, lodging, washing, and uniform. Forms of application may be obtained at the chief offices of the Metropolitan Asylums Board, Norfolk House, Norfolk-street, Strand, W.C., where they must be delivered, duly filled up, by 10 a.m. to-morrow (Saturday).

CITY OF WESTMINSTER ELECTRICAL SYNDICATE (LIMITED).—At meetings of the members held on April 13th and May 4th it was resolved and confirmed that the syndicate be wound up, and that Captain E. I. Bax, 32, Victoria-street, Westminster, S.W., be the liquidator.

CHANGE OF ADDRESS.—The address of the Civil and Mechanical Engineers' Society will be in future 12, Delahay-street, Westminster, London, S.W.

INTERNATIONAL OKONITE COMPANY (LIMITED).—Mr. G. R. Murray, 93, Hope-street, Glasgow, has been appointed agent in Scotland for the Company.

THE LONDON ENGINEERING EXCHANGE.—This exchange will be declared open officially in the Exchange Room of the Jerusalem, Billiter Buildings, E.C., on Tuesday next, the 31st inst.

MESSRS. J. AND W. WEEMS.—We have received from this firm their newly-issued catalogue of special machinery, including their patent hydraulic pipe presses for the lead trades. Amongst Messrs. Weems' specialities is their machinery for producing one to four lead pipes or rods at one operation, and covering with lead telegraph and telephone cables or electric light conductors in long lengths, and also leads for accumulators. Many of the leading electrical firms are users of Messrs. Weems' machinery.

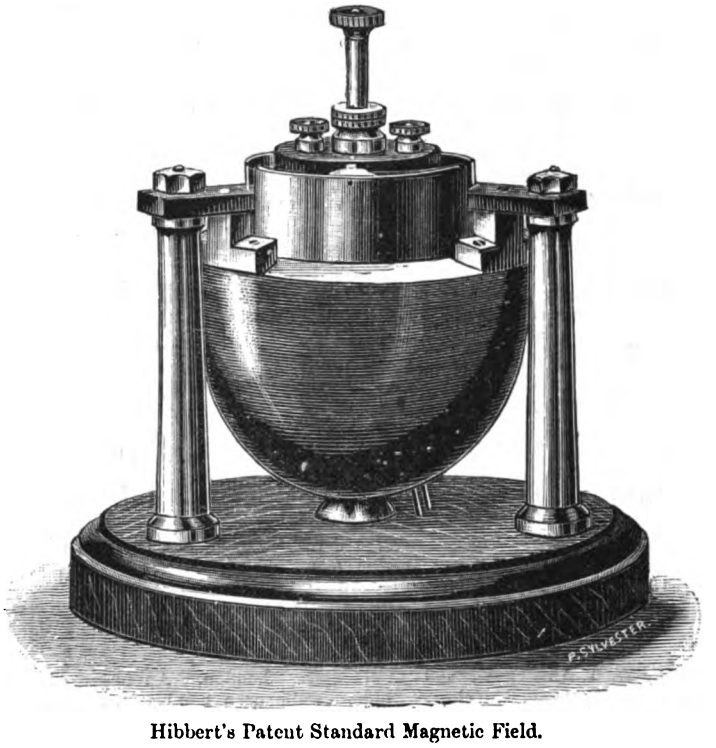
MR. W. S. SARGEANT.—The new electric launch "Myionu," built by Mr. Sargeant, is now complete, and has left for Windsor. Her length is 35ft., beam 5ft. 8in., draught aft 18in. She was built for Captain Homfray, of the Horse Guards. Her hull is constructed of mild steel, and is fitted with a handsome teak cabin. The electrical power consists of 40 E.P.S. accumulators, with high-speed propeller connected up direct with the armature shaft, and rotating at about 650 revs.

MESSRS. SHEETON AND PAGE.—This firm have just installed a complete plant for 50 lights in the offices of the Commercial Telegram Bureau, Tokenhouse-yard, E.C.

GLASS PIPES.—An American journal is responsible for the statement that Mr. R. G. Guptell, glass manufacturer, of Anderson, Ind., U.S.A., has rediscovered the lost art of casting glass pipes, which is claimed to have been carried on by the ancient Egyptians. A factory has been erected at Pendleton, and the first glass castings have been successfully made.

WRAY ELECTRICAL ENGINEERING COMPANY.—We are notified that this Company has commenced business at the Soho Electrical Works, Thornton-road, Bradford, and that the Company has several installations in hand, including the lighting of Rufford Lodge for Mr. C. B. Crawshaw. The firm are manufacturing electricians and electrical engineers, and are manufacturers of, amongst other specialities, the "Soho" Patent Dynamo. Mr. Cecil Wray has the management of the business.

MAGNETIC STANDARD.—Hibbert's patent standard magnet, which was described in *The Electrician*, Vol. XXVIII., p. 178, is being manufactured by Mr. C. Bowron. The instrument consists of a



Hibbert's Patent Standard Magnetic Field.

steel magnet enclosed in an iron bowl. A coil of wire is allowed to drop in the air gap between the magnet and the bowl. The real use of the instrument is to give a standard electromotive force of a uniformly impulsive character.

MESSRS. WOODHOUSE AND RAWSON UNITED (LIMITED).—This firm has opened a branch office and show-room at 22, Rue Lafitte, Paris, which will be the chief depôt for their French trade, and all communications regarding same should be addressed to Mr. E. Kenealy, the manager there. We understand that Mr. E. H. Cadiot no longer represents the firm in France.

"BIBLIOTHECA ELECTROTECHNICA."—Under this title Mr. F. von Szczepanski, of St. Petersburg, has prepared a very useful compilation of the chief English, American, French, and German electrical books and publications. The list gives the size, price, and name of publisher, and the entry in the list is made in the language in which the book is written. Where the book is translated from the original this is clearly shown. The little work is published here by Sampson Low and Co., at 1s. 6d.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

May 3, 1892.

8,291. J. W. EWART. London. Improvements in arc lamps.

8,294. J. C. B. TAYLOR. Holloway. The electric light advertisement.

8,367. J. R. HUGHES. London. Improvements in incandescent electric lamps.

8,385. W. F. TAYLOR. Croydon. Improvements in electricity meters.

8,397. F. A. HASELWANDER. Manchester. Improvements in the method of and apparatus for transforming and distributing electric currents.

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8,399. J. W. PARAMORE and H. THEAKER. Sheffield. Electrical or galvanic braces.
8,408. I. CLIFFORD. London. Improvements in electric incandescent lamps.
8,452. A. CHAPMAN. London. Improvements in driving certain machines by electro-motive power.
8,463. C. COERPER. London. Improvements in electric arc lamps.

May 5, 1892.

8,493. R. WHITEHEAD and A. DOXEY. Sheffield. Improved telephone transmitter.
8,507. C. MILES. Bristol. Electric time-check, call-bell, and registering apparatus.
8,529. W. MOSELEY. London. Improvements in galvanic batteries.
8,535. W. FOWLER. London. Electrical hose signalling apparatus.
8,537. W. E. LANGDON. Derby. Improved electric light switch.
8,556. O. PATIN. London. Improvements relating to alternating-current electric machinery.
8,572. H. BECKMANN, E. BECKMANN, and J. SCHMITT. Glasgow. An improved galvanic element.

May 6, 1892.

8,576. E. H. P. HUMPHREYS. London. Improvements relating to the measurement of electrical currents.
8,611. R. C. KRUSCHKE. London. An improved electric alarm for show cases.
8,638. T TOMLINSON. London. Improvements in electric mains.
8,642, E. F. CARPENTER. London. An improved holder for holding shades or globes of electric, gas or other lamps.

May 7, 1892.

8,663. H. F. JOEL. London. Improvements in the cores of electro-magnets for motors and other purposes.
8,706. S. A. MOORE. London. Improvements in electrical fittings, such as ceiling roses, and cut-outs.
8,720. W. T. GOOLDEN and S. EVERSHED. London. Improvements in electric meters.

May 9, 1892.

8,743. A. SHIELS. London. Improvements in couplings for electric wires.
8,745. B. M. DRAKE and J. M. GORHAM. London. Improvements in switches for electric light work.
8,768. W. P. THOMPSON. Liverpool. Improvements in and relating to mechanically driven alternating dynamo-electric machines combined with an electric lamp (H. S. Hellebrandt, Austria).

May 10, 1892.

8,805. H. N. PRENTICE. London. Improvements in dynamo-electric machines and electric motors.
8,837. T. ARMSTRONG and C. HASCALL. London. An improved non-consumable electric light candle or a non-consumable candle for arc lamps.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

8,961. CAMPBELL. Measuring electric currents.
9,107. BARNES. Electric light fittings, &c.
9,555. GWYNNE. Electric lamp carbons.
10,425. DICKINSON. Electrically illuminating roundabouts, &c.
10,548. SHARROW. Winding electrical wires.
10,703. JOBSON. Telegraph pole attachments.
18,421. ORMES. (Trippe). Electric lighting system.
19,617. MÜTHEL. Galvanic batteries.
22,718. BURTON and ANGELL. Heating metals by electricity.
22,720. ANGELL. Heating metals by electricity.

1892.

4,157. TAYLOR. Electric glow lamp shades.
4,586. THOMPSON AND SANDERS. Magnetic separators for ore, &c.
5.256, LAKE. (Thomson-Houston International Electric Co.) Electric railway conductors.

COMPANIES' MEETINGS.

Taunton Electric Lighting Company (Limited).

A meeting of the shareholders of the Taunton Electric Lighting Company (Limited) was held at the Municipal Hall, Taunton, on Thursday week, to consider what steps shall be taken with respect to the disposal of the works to the Town Council. It appeared that on the previous Monday the Managing Director of the Company had an interview with the special committee of the Town Council with regard to their taking over the works, when it transpired that even if the Town Council obtained a Provisional Order, it would not come into operation until July, 1893, whereas the Company in its present position felt they could not carry on the business until then, unless some arrangement was made in reference thereto. It was suggested that the Town Council should allow the Company to continue working under their supervision, or that the Town Council should rent the works until July, 1893. It was necessary that something should be done promptly, as one customer was waiting to be supplied with 100 incandescent lights, and the Company were unable to supply them owing to want of capital. The result of the interview was that it was agreed to write the Local Government Board, to ascertain whether they would be willing to receive a joint deputation from the Corporation and the Electric Light Company, to discuss the question of carrying on the works until the Provisional Order could be obtained. It was stated at the meeting that no reply had been received to that letter, and after considerable discussion the following resolution was passed :—

"The shareholders advise the Directors to continue the negotiations for the sale of the Company's undertaking to the Town Council for the sum of £9,300, as from July 1st next."

New Shanghai Electric Company (Limited).

The annual meeting of shareholders of this Company was held at the offices, 14, Szechuen Road, Shanghai, on April 14th; the Chairman, Mr. J. Beattie, presiding.

The CHAIRMAN said: Gentlemen, I propose to tell you as much as I can regarding the Company's position generally, and thereby anticipate your questions and thus expedite the proceedings. I hope that you feel satisfied with the report and accounts sent you some time ago, and with your consent we will consider them as read. You will see that we have had no difficulty in maintaining the previous 7 per cent. dividend, after writing off a liberal sum for depreciation. The attempt made last year, to obtain subscribers for the remaining Tls. 50,000 (about) of the authorised capital, fell through, partly owing no doubt to the commercial depression then prevalent. This was indeed unfortunate, as we could easily employ the whole of the additional sum in fulfilling the numerous applications made for incandescent lighting. Outside installations, in steamers, &c., are progressing steadily; but I may point out that, as regards materials sold, no profit is charged on fittings to consumers supplied from the Company's mains. All the plant is in good order and condition, and it will be satisfactory to you to know that Mr. Prentice, whose opinion I am sure you think perfectly reliable, has assured us that the machinery could not be replaced at anything like the present valuation shown in the accounts. The time has now come when the ordering of further machinery is absolutely imperative, and we have here, already drawn out, a telegram ordering what is simply indispensable without any further delay, but which we have determined to keep over till after this meeting, so that you should be quite posted up to date regarding the actual position of the Company. The amount involved in this order is only about Tls. 15,000; and if the shareholders between them do not underwrite this sum, which will not be called up for several months, the Directors will have to fall back on other provisional arrangements they have made. We are aware that the quoted price of shares makes the issue of more capital at par a difficult matter; in our opinion, however, the position and prospects of the Company do not warrant the shares being at a discount, but that is a matter entirely beyond our control, and for this additional outlay, in which we are quite prepared to take our share, we can only appeal to the public spirit of our shareholders, and we hope not in vain. The charge proposed for Directors' fees looks heavy, but it covers a long period, during which three retired and the three remaining members of the Board (amongst whom the fees will be divided) have had arduous and trying duties to perform.

The Directors' report and accounts recommending a 7 per cent. dividend were then adopted, and the retiring Directors and auditors were re-elected.

After some feeling remarks from Mr. Douglas Jones as to the able services rendered by Mr. Porter, their secretary, a vote of thanks to the Chairman terminated the proceedings.

Elmore's French Patent Copper Depositing Company (Limited).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel on the 21st inst., Major Charles Jones in the chair, when the following extraordinary resolution, which was passed at the general meeting of the Company held on the 22nd ult., was submitted for confirmation as a special resolution :—

"That the capital of the Company be increased to £400,000, by the creation of 100,000 new shares of £3 each. Such new shares shall be called Preference Shares, and shall be entitled to priority on a distribution of assets, and shall also be entitled, out of the profits available for distribution in each year, to a preferential dividend of 10 per cent., and to a further dividend of 5 per cent. after a dividend of 15 per cent. has been paid on the existing shares of the Company, which shall in future be called Ordinary Shares."

The Secretary (Mr. J. SHURMER) having read the notice convening the meeting,

The CHAIRMAN observed that, as no dissent was expressed at the last meeting to the proposal, there was no necessity for him on this occasion to give any explanation with reference to the matter. He might, however state that very good reports had been received from France, where everything connected with the Company's affairs was going on well. A circular letter of the Company had been issued since the 22nd ult., and the replies already received had been very satisfactory. Trial and other orders had been sent in from a large number of houses, including some of the best firms in France. These orders were now being executed, and the work was progressing in a very satisfactory way. He concluded by proposing the confirmation of the resolution as above.

Sir JAMES MACKENZIE seconded the motion, when a short discussion followed, and, in reply,

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The CHAIRMAN said that any engineer or manufacturer would tell them that it took a considerable time to get to work first of all, even if they had the orders, and then it would take a considerable time to work the factory up to the full output. They had to get the whole organisation in order. They had only been able gradually to bring the tanks into operation: and what they reported at the last meeting—M. Secrétan's report—was the correct statement, namely, that there were 80 tanks, turning out about 100 tubes a day, at work.

A SHAREHOLDER: And that is so now?

The CHAIRMAN: Yes. The output is approximately perhaps a little better than it was then; but the actual output of tubes for sale has not increased very materially, for the simple reason that we have been occupying some of the tanks, which would otherwise have been making tubes for sale, in coating mandrils with copper, and in making duplicate mandrils, so as to be in a position to go on steadily with the work, and not have to stop the tanks while waiting for mandrils. We are turning out about nine to ten tons a week.

A SHAREHOLDER stated that a letter of the Chairman of the Company, dated the 1st of January, informed the shareholders that he had started the works, and that they were capable of turning out 80 tons a month.

The CHAIRMAN stated that the view taken by the shareholder of the letter in question was mistaken. It was not 80 tons a month, but approximately 80 tons a week. That, however, was what the factory was erected ultimately to produce; it was 300 tons a month. The only report that the Chairman of the Company made was that he had started the first two tanks, showing that the works were in order; but that was a very different thing from working the factory at its full output.

A SHAREHOLDER: I understand that you now produce about ten tons a week?

The CHAIRMAN: Yes, and we shall go on increasing that. M. Secrétan is pushing on as fast as he can, and he is gradually bringing more tanks into use every week. In answer to other questions, the Chairman, continuing, said that if any shareholder would call at the offices, the Secretary would be very glad to give him information as to the returns which were periodically received by the Company from France. With regard to the preference capital, the amount they had allotted was between £24,000 and £25,000, and the Board were, in addition, making arrangements, under certain conditions which they saw no difficulty in fulfilling, for placing another £40,000.

A SHAREHOLDER: Why do we want so much preference capital as you propose?

The CHAIRMAN stated that they only took power to issue £120,000. This was to pay for the extra expenses of the factory and to provide working capital to go on with. The original working capital was not sufficient to carry them on during the time they had been a Company, and to pay for the large factory which had been erected.

A SHAREHOLDER inquired who was responsible for the excessive liabilities which had been incurred.

The CHAIRMAN stated that the outlay had been authorised by the Directors. They had power to borrow money up to half their capital, and the Board had exercised their authority in the interest of the shareholders.

A SHAREHOLDER: When will you come to turn out 300 tons a month?

The CHAIRMAN said that he could not give an accurate answer to such a question, but assured the meeting that all possible speed would be made to arrive at a full output.

The resolution was then put to the meeting and was confirmed *nem. con.*, the meeting afterwards separating.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

CAMBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).—This Company was registered on May 18th, with a capital of £50,000, in £10 shares. The objects for which the Company is established are to carry on the business of electrical engineers, electrical contractors and undertakers for the supply of electricity for lighting, transmission of power and any other purposes; and to promote, support and obtain any Acts, Provisional Orders, licences and other authorities necessary or desirable for the carrying out of any of the objects of the Company, and in particular to take a transfer of the powers, duties and liabilities granted to and imposed upon the Mayor, Aldermen and Burgesses of the Borough of Cambridge, by the Cambridge Electric Lighting Order, 1890. The first Directors are William Bond, Sir Benjamin C. Browne, Gerard B. Finch, the Hon. Charles A. Parsons, John B. Simpson and George Whitmore.

MISCELLANEOUS.—EDWIN HAMPTON (LIMITED), electrical and general engineers, iron, and brass founders, &c.; capital, £10,000, in £5 shares.—PUBLIC WORKS TRUST (LIMITED): constructors of all kinds of public works in Italy and elsewhere.

ANGLO-GENERAL ELECTRIC LIGHT COMPANY (LIMITED) (IN LIQUIDATION).—A notice has been filed announcing that at a meeting of this Company held on May 10, 1892, for the purpose an account was furnished, showing the manner in which the winding up of the Company had been conducted and the property of the Company disposed of. The Company was registered on November 8, 1881, with a capital of £24,000, in £1 shares, to acquire by purchase or otherwise and to work all or any of the inventions of, and the patents and patent rights granted or to be granted to, Leonard Jules Bouteilloux and William Laing, both of Paris, for improvements in means or apparatus for producing and applying electricity for lighting, motive power and otherwise, for improvements relating to dynamo-magnetic electro machines, for improvements in electric lamps, and all other matters and things in any way or manner connected with electricity and the means of producing, transmitting, distributing and applying the same. By special resolution passed and confirmed in April, 1883, it was determined that the Company was to be wound up voluntarily, and Mr. Charles F. Reynolds, of 13 and 14, King-street, Cheapside, E.C., was appointed.

BATH ELECTRIC LIGHT COMPANY (LIMITED).—This Company has been dissolved under Clause 7 (4) of the Companies Act, 1880 (43 Vict., ch. 19), by notice in the *London Gazette*, dated May 10, 1892. The Company was registered on March 21, 1889, with a capital of £25,000, in £10 shares.

BENHAM AND FROUD (LIMITED).—The annual return of the above-named Company, made up to the 11th inst., was filed on the same day. The Company was registered on July 29, 1885, with a capital of £50,000, in £10 shares. At the time of making up, 2,907 shares had been taken up, and, according to the return, all have had the full amount called, thus resulting in the payment of £28,852. 10s., and leaving £217. 10s. in arrears.

CHLORIDE ELECTRICAL STORAGE SYNDICATE (LIMITED).—The statutory return of the above-named Company, made up to May 4, 1892, was filed on the 20th inst. At the time of making up 48 founders' and 11,927 preference shares had been taken up, and a call of £1 per share had been made, resulting in the payment of £9,965. 10s., and leaving £2,008. 10s. in arrears.

ELECTRIC "SUN" LAMP AND POWER COMPANY (LIMITED) (IN LIQUIDATION).—A notice has been filed notifying that a meeting has been called, and has received an account showing the manner in which the winding-up of the Company had been conducted and the property of the Company disposed of. The Company was registered on June 26, 1882, with a capital of £200,000, in £5 shares, to purchase the patent rights of an electric lamp called the "Lamp Soleil" for the United Kingdom and elsewhere, and the right of manufacture and use of certain other inventions connected with electricity, and to carry on the business of an electric light and power company in all its branches. By special resolution, passed September 25, 1885, and confirmed October 15, 1885, it was determined that the Company should be wound up voluntarily.

ORIENTAL TELEPHONE COMPANY (LIMITED).—The annual return of the above-named Company, made up to the 11th inst, was filed on the 16th inst. The nominal capital is £300,000, divided into 225,000 ordinary and 75,000 vendor's shares of £1 each. Of these, 223,494 ordinary and all the vendors' shares have been taken up, of which, 3,494 ordinary and the vendors' shares have been issued as fully paid. Upon the remaining 220,000 ordinary shares 11s. per share has been called, and all calls have been paid.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 22nd were £767, as against £768 for the corresponding period of last year, being a decrease of £1. The total receipts to date, from January 1st last, amount to £16,696, against £15,375 in the corresponding period of 1891, being an increase of £1,321.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to appoint special settling day in, and to grant a quotation to £98,400 additional Four per Cent. Mortgage Debentures.

ELECTRICITY SUPPLY CORPORATION (LIMITED).—Application has been made this week for £70,000 in 700 £5 per cent. debentures of £100 each, redeemable at par in 1900. The interest is payable half-yearly, and the debentures may be paid off at any time at £105 after six months' notice; £10 is payable on application, and the balance on allotment. The lists closed yesterday for London, and this day (Friday) for the country.

ISLINGTON AND GENERAL ELECTRIC SUPPLY (LIMITED).—Applications are invited by the Exploration Company (Limited) for 45,000 £5 shares in the above Company, payable 10s. on application, 10s. on allotment, and the balance in sums of £1 on June 30, August 31, October 31, and December 30, 1892. The share capital of the Company is £250,000, and the present issue is for £225,000. Included in the Directorate are Sir Frederick Abel, K.C.B., F.R.S., and Mr. R. W. Wallace, of the Westminster Electric Supply Company. The Engineers to the Company are Prof. A. B. W. Kennedy and Mr. V. B. D. Cooper; the Consulting Electrician is Mr. Gisbert Kapp; the Secretary is Mr. R. McA. Inglis, and the offices of the Company are situated at 5, Victoria-street, Westminster, S.W. The prospectus states that the Company has obtained Provisional Orders for supplying the electric light in the parishes of Camberwell and Islington, these Orders running for 42 years from 1889. As both these districts are very populous, it is anticipated that a very large business will be done by the Company, more particularly as they have been successful in opposing applications by competing companies for Board of Trade Orders for the parishes represented. The first station to be erected is to be on the low-tension system, and a contract has been entered into with Messrs. J. E. H. Gordon and Co., (Limited) by which they agree for the sum of £144,000 to provide a site for the first station, and erect and equip two stations in Islington with a capa-

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city of 37,000 lights burning simultaneously, to lay mains, and to pay the cost of the flotation of the Company up to allotment, &c., &c. Under this arrangement, the first station is to be completed within eight months from the entry of the contractors upon the works. Tenders will be invited for the erection of a station at Camberwell. The subscription lists will open on Monday next, the 30th inst., and close on or before Tuesday, the 31st. Further particulars will be found in our advertisement pages.

RUSTON, PROCTOR AND COMPANY (LIMITED).—The Directors, in the balance sheet made up to March 31, 1892, say that the trading results for the year show a balance of £49,271 10s. 10d., from which has been deducted depreciation of plant and machinery and Directors' remuneration, leaving £44,983 8s. 10d. Out of this there has been paid the interest on the debentures and the interim dividend of 5s. per share, paid October 1, 1891, leaving a net balance of £26,233 8s. 10d. The Directors propose the payment of a dividend of 10s. per share, making, with the interim dividend, 7½ per cent. for the year.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).—The numbers are announced of 86 bonds of £100 each of the Six per Cent. Mortgage Debentures, for payment at par on and after June 30th next.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended May 20, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,803.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 18.	Price Wednesday, May 25.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending May 25. Highest.	Lowest.
			TELEGRAPHS.						
£1,300,980	Stock	12'6	Anglo-American	48½ 49½	48 49	5 12 3	Jan., Apr., July, Oct.	48½	48½
£2,849,510	Stock	25/0	Do. Preferred	88½ 89½	88 89	5 18 0	" "	89½	87½
£2,849,510	Stock	5/0	Do. Deferred	11½ 12	11½ 11¾	..	" "	..	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½ 11	10½ 11	7 5 6	Mar., June, Oct., Dec	10¾	10½
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	104 108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	158 163	158 163	4 5 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	11⅞	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	16¾	16½
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3¾	3½ 3¾	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½ 11¾	11½ 11¾	5 19 2	Jan., Apr., July, Oct	11¾	11½
400,000	10	2/6	Eastern	14½ 15	14½ 15	4 6 8	" "	15	14½
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16½	15½ 15¾	3 16 2	" "	15¾	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	110½	109
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	108½	..
250,000	10	6/6	Eastern Extension xd and bonus	14⅞ 15½	14⅞ 15½	4 12 7	Jan., Apr., July, Oct.	15⅛	14¾
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 1	February & August	..	..
£78,8 0	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	104½	103½
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb..1900	102 105	102 105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	101 104	3 16 11	February & August	101¾	
180,227	10	2,0	Globe Telegraph and Trust	10½ 10¾	10½ 10⅝	5 1 2	Jan., Apr., July, Oct.	10⅝	10½
180,042	10	6%	Do. 6 per Cent. Preference	15⅜ 15⅝	15⅜ 15⅝	3 16 10	" "	15⅝	15½
150,000	10	7/2	Great Northern xd	18½ 19½	18½ 19½	4 9 2	Jan., April, and July	18⅝	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	103 109	106 109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	39 41	40 42	5 19 1	May and November	41	40½
38,348	10	4,0	London Platino-Brazilian xd	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	6 7	6½ 7½	5 6 11	April and October..	7½	6½
3,381	£100 Cert.	£1¼	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	115½	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	99½	..
80,000	10	2,0	West Coast of America	3½ 4½	3⅝ 4½	5 11 1	January and July ..	3¾	3½
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	..	..
88,321	10	1,0	West India and Panama	1⅛ 1⅜	1⅛ 1⅛	..	" "	1⅜	1⅜
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	10½	10½
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
67,007	15	6,0	Western and Brazilian	9½ 10	9½ 10	7 10 5	" "	9¾	9½
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 3	" "	6¾	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	3½ 4	3½ 4	..	" "	3¾	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105 108	105 108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105 108	105 108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	115 119	115 119	5 17 8	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
234,850	14/0	4·034	Consolidated Telephone Const. & Maintenance.	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
x20,000	£1	4½d.	Oriental (11s. paid)	1/16 1/8	1/16 1/8	6 3 11	Yearly	..	..
438,984	5	2/6	National	4¼ 4½	4¼ 4½	6 13 4	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13 13½	13 13½	4 14 1	" "	13½	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12½ 12¾	12½ 12¾	4 14 0	" "	12⅞	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	107 109	107 109	4 2 7	January and July ..	109¾	108½
58,000	5	1/0	United River Plate	1½ 2½	1½ 2½	..	" "	..	..
£146,870	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£8 paid)	7⅛ 8	7⅜ 8½	..	..	8⅛	7⅞
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
38,332	£5	..	House to House Electric	2½ 3½	.. ..	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½ 6	.. ..	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 6	.. ..	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s paid)	3⅞ 3⅞	3⅞ 3⅞	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5⅛ 5⅜	5⅛ 5⅜	..	March	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid) xd	7½ 8	7½ 8	..	..	7¾	7½
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½ 5½	4 5	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8½ 9	8½ 9	..	..	..	..
7,900	£5	7%	Do. 7% Preference	7⅞ 8½	8 8½	..	..	8½	8⅛
42,853	5	..	Westminster Electric Supply (fully paid)	6½ 7	6½ 7	..	..	6¾	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1 9	Brush Electrical Engineering	3 3½	3 3½	..	..	..	..
69,996	2	6%	Do. 6 per Cent. Preference	2 2½	2 2½	5 2 7	..	2½	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5¾	5½ 5¾	5 16 8	January and July ..	5½	5½
17,130	5	17½	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	12,0	Electric Construction	5¾ 6½	5¾ 6½	..	..	6	5¾
70,000	2	10/0	Elmore's Patent Copper Depositing	2½ 2¾	2½ 2¾	..	..	2⅞	2½
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½ 20½	19½ 20½	6 1 11	February & August	20½	19½
£ 09,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 105	102 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4 5	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼ ⅜	5/16 7/16	..	..	..	..
78,949	5	2,0	Swan United (£3. 10s. paid) xd	3¾ 4¼	3½ 4	9 13 0	May and November	3½	..
36,250	12	30/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 1	March and July....	43¾	43½
150,000	100	5%	Do. 5 per Cent. Bonds, red 1894	101 104	101 104	4 16 2	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅜ ½	.. ..	..	..	..	..
..	£5	8%	Do. Preference (fully paid)	2½ 3	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
60,000	£10	..	City and South London Railway	2½ 3½	2½ 3½	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

A full report of the annual general meeting of the Electrical Trade Section of the London Chamber of Commerce will be found elsewhere in the present issue. Although many matters of considerable importance were discussed, the attendance was, as usual, somewhat meagre, not more than 15 per cent. of the members of the Section being present. The election of Major Flood Page as Chairman will, we think, commend itself to the industry at large, and the influx of a little new blood in the shape of the election of Mr. Alexander Siemens as one of the Vice-Chairmen shows that the Section is alive to the danger of getting into a groove. It is to be hoped that the prompt appointment of a Committee to consider the electric traction and telephone question will render the formation of yet another Association unnecessary. As several speakers remarked, the tendency of the electrical industry to split itself up into minute sections is greatly to be deprecated.

There was evidently an Oliver Twist spirit abroad at the Institution of Electrical Engineers last week. In spite of the array of figures with regard to last year's working of the Newcastle Electric Supply Company, most of the speakers "asked for more." Some additional data were obligingly supplied on the spot by Messrs. Heaviside and Jackson, and others were promised for the *Journal*. The discussion, though brief, was one of the best we have had this Session, being, with the exception of a momentary lapse into an interchange of views as to the relative merits of open and closed circuit transformers, rigidly confined to corroboration or confutation of statements advanced in the Paper just read, and it was not, as is too often the case, a mild conversation upon things in general.

Mr. Crompton was of opinion that the figures given by the authors of the Paper bore out his contention that alternate-current high-pressure distribution is more or less an expensive luxury; and he proceeded to asperse the character of alternators for efficiency, which resulted in a challenge from Mr. Mordey—which was promptly accepted—to run representative dynamos of either kind upon a bank of lamps at the Crystal Palace, the machine which ran the larger number for a given indicated horse-power to be adjudged the victor. On the other hand, as Mr. Preece justly observed, alternate-current companies, owing to their comparatively low capital expenditure, can afford to spend more money on distribution than low-pressure concerns. In the case of the Newcastle Electric Supply Company the total capital expenditure comes out at 30s. per lamp installed, made up as follows: Buildings and land 2s. 8d., station plant 13s. 1d., switchboard 7d., pipes and boxes 4s. 7d., mains 4s. 7d., loose plant 4d., transformers 4s. 2d.

Sir David Salomons was apprehensive lest the figure of 4½d. per B.T.U. charged at Newcastle should get abroad without qualification, and showed that taking gas in London at 3s. against 1s. 10d. at Newcastle, the equivalent price of electricity in London worked out at practically 8d., so that Londoners had nothing to complain of. Difficulties have arisen in Newcastle in regard to working alternators in parallel owing to the irregular running of the engines. To remedy this defect, the authors of the Paper proposed heavy flywheels or springs placed between shafting and pulley; a correspondent this week opines that the valves should be looked to.

The research forming the subject of the interesting Paper by Messrs. Edser and Stansfield, which was read at a recent meeting of the Physical Society, was suggested by the calls which have been made upon the Kew Observatory for the examination and certification of so-called non-magnetisable watches. Ever since dynamos have been in commercial use those employed about them have either protected their watches by an iron case or sheath or have had alterations made to the movements. The commonest watches often escape injury altogether, and trouble generally is found in the magnetisation of the balance-wheel of compensated watches. But in low-class watches the compensation is often a mere dummy, and the time-keeping qualities are in no way affected by replacing the balance by a plain one of gold or brass. The hair-spring occasionally gives trouble, and the coils may even stick together after exposure to a strong field; but a phosphor bronze spring, though difficult to adjust, behaves very well. M. Paillard has used alloys of palladium, but manganese steel is obviously the best material for the purpose. The lever also may with advantage be made of manganese steel, but as the ruby pallets prevent metallic contact, it does not give much trouble.

It is to be hoped that either Messrs. Edser and Stansfield will continue their researches, or that the Kew Committee will make some investigation as to the strength of field which

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is likely to temporarily affect or to permanently injure watches of various makes and qualities. At the Paris Exhibition of 1881 we experienced the inconvenience of the magnetisation of a watch, and after demagnetising it by spinning, replaced the compensated balance by a wheel of plain gold. A phosphor bronze spring was tried, but gave bad results. Although the watch contains an unusual amount of steel work in the chronograph motion, it has never been affected since by proximity to dynamos. The balance-wheel is arrested by eddy currents in a powerful field, and the watch as a whole is strongly magnetic, but goes very well considering that it is not compensated.

Apart from its bearing on the injury to watches, the investigation of the stray field of dynamos both as regards direction and strength by means of the instrument described in the present number would be of considerable interest. Curves of the direction of the lines of force in the neighbourhood of a dynamo are in themselves very instructive, showing clearly how and where leakage takes place. But by means of this instrument another set of curves of equal strength of field might be added, intersecting the former everywhere at right angles. Theoretical diagrams as given in the plates at the end of Maxwell are easy enough to draw, but the actual disposition of the field round a dynamo is very difficult to guess.

In a short article which we publish this week, Mr. Carl Hering proposes to use the term "ampere-centimetre," or some equivalent expression, as the unit number of lines of force, and gives reasons which show that the dimensions of the unit of magnetic flux are the same as those of an ampere multiplied by a length. Although, however, it may be perfectly justifiable, as far as dimensions are concerned, to express a number of lines of force as so many ampere-feet, it is quite erroneous to assume that the number of lines of force produced by the current flowing in a circuit is proportional to the number of amperes multiplied by the number of feet of wire composing the circuit. The error in Mr. Hering's argument lies in his assumption that his quantity K is constant. As a matter of fact this ratio varies very much for different sizes and shapes of circuit, whether there is any magnetic substance like iron in the neighbourhood of the conductors or not.

The number of lines of force produced by a current C in any circuit is equal to the product L C, where L is the coefficient of self-induction of the circuit. L is a quantity whose dimensions are those of a length, so that Mr. Hering's first contention is quite justifiable; but in order that the number of lines produced may be proportional to the current multiplied by the length, it is evidently necessary that the self-induction of a circuit of given length must be the same however the wire is wound, and this cannot be even roughly true in the general case. With certain restrictions, however, it is quite possible that the proportionality holds; and when these conditions are fulfilled, the simple rule, that the flux of lines produced is proportional to the magnetising current multiplied by the length of wire conveying it, becomes a useful working formula.

On investigation we find that the following conditions are necessary in order that the number of lines of force in a magnetic circuit may be proportional to the number of ampere-feet of magnetising wire. The magnetic circuit must be very good, as in a dynamo machine in which little magnetic leakage occurs, and, if the number of lines per ampere-foot is to be the same for different dynamos, the iron must be of the same quality and magnetised to the same state of saturation, so as to have the same permeability, and the dynamos must be of the same type, that is, the ratio of the length of the magnetic circuit to its diameter must be constant. It is fortunate that these conditions are all very nearly fulfilled in the manufacture of any given type of machine.

The Patin dynamo which we illustrate in another column presents several features of interest, though there is nothing new in principle. Remembering that the inventor was until recently in partnership with Mr. Ferranti, it is not surprising to find that there is some resemblance to the well-known dynamos of which the Deptford station contains such fine examples. On the other hand, the stationary armature and revolving magnets recall the Mordey alternator; but, as far as can be judged from the illustration which we reproduce from *L'Industrie Electrique*, the French dynamo is inferior in mechanical design to either of the English types to which we have alluded. The armature appears to be mounted on a sleeve, which rides on the revolving shaft. The sleeve must fit the shaft closely in order that the clearance may be kept constant, and no adequate provision is apparent for taking the weight of the armature or preventing it from rotating.

The waste of valuable time which always takes place in the Law Courts when an electrical case comes on for trial, owing to the need of conveying to the Judge a clear idea of the meaning of a few technical terms, is only too well known; and any means of reducing the great cost of this elementary instruction is well worthy of the attention of both plaintiffs and defendants. An energetic and apparently successful effort in this direction has been recently made in the American Courts during the hearing of the important "Feeder" and "Main" case, brought on by the Edison Company. In order to save time, quite a collection of physical apparatus was prepared with the view of illustrating each step in the argument. Series and parallel systems of distribution were illustrated by working models, each consisting of a closed system of water circulation. Coloured water was made to flow through glass pipes by means of a rotary pump representing the dynamo, and waterwheels were placed in circuit, either in series or in multiple arc, to represent the lamps or motors absorbing the electrical power. Pressure tubes were also attached at different parts of the circuit to represent the distribution of voltage. Models of a more elaborate kind were also shown in illustration of the various feeder systems of distribution with which the

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case was concerned; and our contemporary the *Electrical Engineer*, of New York, has fully illustrated them in a recent issue. While these latter models refer chiefly to a special lawsuit, and are unlikely to be wanted again, the former are of a much more general character, and, for some years to come, it seems likely that a little money spent in constructing them would be more than repaid by the saving of time they would effect in the hearing of electrical cases in English Courts. Models of machinery are common in our Law Courts, and an elaborate model representing a particular form of distribution was a feature of the Lane-Fox case; but elementary models of series and parallel distribution and the like would be of great value.

Society of Arts.—The annual *conversazione* of this society will take place at the South Kensington Museum on Wednesday evening, June 29th.

Personal.—We understand that Mr. Guy C. Fricker is about to terminate his engagement with the Gülcher (New) Electric Light and Power Company.

Interurban Telephony.—The Paris-Tours telephone trunk line was opened to the public last month, and the Paris-Bordeaux line is daily expected to come into operation. Telephonic communication between Odessa and Nicolaieff (80 miles) has been successfully established.

Private Art Collections in London.—The *Art Journal* for this month contains an interesting account of Sir John Pender's fine collection of pictures. Details of the history of many of them, with several engravings, are given; together with sketches of Sir John Pender's house in Arlington-street.

St. Saviour's District Board.—This Board has received a statutory notice from the City of London Electric Light Company intimating that they intend to apply to the London County Council for permission to erect a wharf on Bankside. The Board have, however, decided to strenuously oppose the application.

Bournemouth.—We may mention in connection with the action (a full report of which will be found in another column) brought by the Western Counties and South Wales Telephone Company against the Bournemouth and District Electric Supply Company, that the mains are principally concentric, with some Silvertown pairs in branches.

Civil Service Commission.—The Civil Service Commissioners will, on June 22nd, hold an examination for the post of Second Assistant to the Lecturers at the Royal Artillery College (20—25). The date specified is the latest at which applications can be received. They must be made on forms to be obtained, with particulars, from the secretary, Civil Service Commission.

Royal Society.—Among the Papers down for reading yesterday were the following:—Major Darwin, "On the Method of Examination of Photographic Objectives at the Kew Observatory;" Lord Kelvin, P.R.S., "On a New Form of Air-Leyden, with Application to the Measurement of Small Electrostatic Capacities;" Dr. J. Larmor, "On the Theory of Electrodynamics as affected by the Nature of the Mechanical Stresses in Excited Dielectrics;" and Major Hippisley, "On Current Curves."

Obituary.—The death is announced of Mr. T. Prime, head of the oldest existing electro-plating firm in Birmingham. In 1842, Woolrich, who in the working out of his ideas had received special facilities at Messrs. Prime's plating works, patented an electro depositing dynamo. This machine, which was employed for a long time by Messrs. Prime—who undertook the working of Woolrich's patent—was presented by them a few years ago to the Corporation of Birmingham, and is now deposited in the museum at Aston Hall.

The City of London Electric Lighting Company and the New Telephone Company.—At the last meeting of the Court of Common Council the Chairman of the Commission of Sewers was asked whether it was true that the Company carrying out the lighting of the City by electricity had given permission to a telephone company to lay their own tubes down at the same time without first asking the consent of the Commission of Sewers. Mr. Treloar replied that he did not know of any pipes being laid except those of the Electric Lighting Company.

Dr. J. A. Fleming's "Alternate Current Transformer."—Owing to the large demand for Dr. J. A. Fleming's Alternate Current Transformer," a third issue of Vol. I. is now ready This volume consists of 500 pages, and is accepted as a text-book on the subject in the Universities and Colleges of Great Britain, the Colonies, and America. Volume II. is in the press, and will be published about the 13th instant. It will consist of more than 600 pages, and will be very fully illustrated. Both books form part of *The Electrician* Series.

The London-Paris Telephone.—Speaking at a meeting of the shareholders of Reuter's Telegram Company, on Wednesday, a report of which will be found elsewhere, Admiral Sir John Hay said that the London-Paris service had involved important structural re-arrangements at the premises in Old Jewry, chiefly in order to secure a room impervious to outside sounds, as only the most expert telephonists were able to catch the sound of the voice coming over such a long distance, and he mentioned incidentally that 8,000 words were heard and recorded within three-quarters of an hour.

The National Telephone Company and its Sheffield Subscribers—At a meeting of telephone subscribers at Sheffield on Monday last, the report of the Subscribers' Committee was presented, and passed after some discussion. It was decided to form an Association of Sheffield Telephone Subscribers. The tariff, as accepted, was practically that published on p. 84 of our last issue. The Committee stated in their report that the National Telephone Company "pledged themselves fully that Sheffield should have the best system that could be given to any centre, even if it involved the adoption of the twin-wire and metallic circuit system."

The Electric Lighting of the City.—After the distressing condition of the main thoroughfares of the City, consequent upon the operations of the City of London Electric Lighting Company, say the *City Press*, it is pleasing to know that their *employés* managed to do a great deal of work in spite of the congested state of the traffic in the streets through which they passed. Trenches were cut at the rate of from 800 to 900 yards per week, and the total quantity cut up to the 14th ult. exceeded 60,000 yards, leaving about 20,000 yards to finish. On the same date 3,630 yards of distributing mains had been laid down, and over 6,000 connections had been made. This was a little more than a fourth of the applications which the Company had on its books.

The Waterloo and City Railway Scheme.—The South-Eastern Railway Company intend, it is understood, to offer a strenuous opposition to the passing of the proposed Waterloo and City Railway. In the petition upon which this Company will appear, after setting forth that the proposed railway will be constructed practically between the same points as those "now efficiently" served by their existing line to Cannon-street, they proceed to allege that the proposed railway is, in fact, projected by the London and South-Western Railway Company, or, at any rate, is introduced solely in the interests of that Company, and is, in effect, an extension of their railway into the City of London. Such a railway, they contend, Parliament would never sanction if it were openly promoted by the South-Western Company, who have, they say, received immense benefit from their railway without contributing one penny either to the cost of the railway or of the Cannon-street Station. The promotion of this railway by indirect means is, they contend, inconsistent with good faith on the part of the South-Western Company, and they submit that it would be a great injustice to enable that Company, by means of the proposed railway, to divert from their system a large amount of traffic which now passes over the most costly part of their railway.

The Electric Railway Promoters and the Proposed Mansion House Subway.—The subway scheme suggested by Mr. H. H.

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Bridgman in 1885 to facilitate the traffic at the much-congested Mansion House centre is likely to be carried out in the near future free of expense to the ratepayers. At a special meeting of the Commissioners of Sewers, on Wednesday last a report of the Finance and Improvement Committee was unanimously adopted, recommending the proposal of the Electric Railway promoters to construct a central station underneath the open space in front of the Mansion House, Bank of England, and Royal Exchange, on condition that a series of public subways be constructed thereat at the sole expense of the railways. The Bills will, therefore, go before the Parliamentary Committee untrammelled by any objections under this head by the City authorities. The access to the subways will be by means of staircases from the public way—descending about 8ft.—at the corner of the Union Bank, in front of the Royal Exchange, by the London, Liverpool, and Globe Insurance Office, by the side of the Mansion House, at Mappin and Webb's corner, and by the Safe Deposit building, and will all communicate with a circular corridor, 15ft. wide, embracing the several points mentioned, lighted by electricity, from which the station will be entered and access gained to the railway level some 60ft. beneath the surface of the street.

The Fire at Scott's Restaurant.—Writing to the *Morning Post* of Wednesday, Mr. E. C. de Segundo says:—

So much misconception seems to have arisen as to the interpretation of my evidence at the adjourned inquest on the above fire that I will ask you to grant me a little space in your paper to correct the distorted views which have been taken of the matter owing to ignorance of the more important facts of the case. The idea seems to have gained ground that my opinion was invited generally as to the cause of the fire, and that the tendency of my evidence was to the effect that electric light in a house is a source of danger and risk of fire. These views are inconsistent with the facts of the case, with the intention of my evidence, and with the finding of the jury. You will doubtless recollect that the question of the electric light as a possible cause of the fire arose only at the end of the first inquest, some of the jury stating that, as the fire had broken out in that part of the premises lighted by electricity, they thought that the opinion of an expert should be taken on the possibility of the electric light having been the cause of the fire. The Coroner then adjourned the meeting for a week, and invited my opinion as an expert in the matter of wiring of houses for the electric light, on the following point—Whether or not it is possible for defects in the system of putting up electric light wires to cause a fire, and if so, whether or not there were evidences of any such defects having existed in the system of wires as erected at Scott's Supper Rooms. I will ask you to note that I was not called upon in the first instance to discover the cause of the fire, but to report upon the possibility of a connection between the electric wiring in a house and a cause of fire, with particular reference to the fire at Scott's. I found certain defects which would never have existed had the work been done under competent supervision, and which I mentioned in my report and in my evidence; but my answer to a juror, which really sums up my opinion on the matter (and which was reported in *The Standard* of the 21st ult.), was as follows:—A juror: Do you consider that the fire was caused by the electric light? Answer: I think it is distinctly possible, but I find no definite tangible evidence to that effect. This, I think, should sufficiently dispose of the wrong impressions which seem to have arisen. . . .

Thunderstorms.—On Wednesday last week the midland and eastern counties were visited by a severe thunderstorm. At Epworth a house was badly damaged. At Derby the old parish church of St. Werburgh's, which is shortly to be rebuilt, was struck, and one of the pinnacles of the tower was displaced. At Gainsbro' the signal-box on the Great Northern Railway at Lea was struck, the instruments were damaged, and the lightning conductors fused. The discharge melted wires and set fire to wood work in no less than five places. Near Whitby a lad was killed by lightning as he was crossing the railway just outside a village. At Retford, portions of the wooden sheds, which are in course of erection in connection with the forthcoming Notts Agricultural Society's Show, were struck, and four of the workmen injured. At Rockley, a servant was struck by lightning. In London, on Thursday last week, the alarm-bell communicating with the fire-post in East-street commenced ringing violently in the Old Kent-road Fire Station. The members of the brigade turned out, but found that the lightning had struck the wire and started the bell. On Tuesday last a storm burst over Bishop Auckland, during which a fatal lightning stroke occurred at Shildon. On Wednesday a violent thunderstorm occurred at Bristol, and caused serious damage to University College. The lightning struck a large stone figure weighing 5 cwt., which was destroyed. An immense block of 2 cwt. fell through the electricians' room, smashing the roof and destroying the electrical apparatus. A student had a most narrow escape. At Manchester on Wednesday the resident engineer for the Salford Sewage Works was walking along the banks of the Ship Canal when he was struck by lightning and killed. At West Bromwich, a stoker was struck by lightning and severely injured. Reports of great loss of life and property in France during the storm of Tuesday have been received. At Montauban, a woman was killed by lightning. At Perpignan a church belfry was struck and destroyed. A labourer, while working in the fields near Nantes, was struck dead, and at Charmes-la-Côte the lightning struck a tree under which six persons had sought shelter, killing three and severely injuring two others.

Actinism.—In a Paper recently read before the Franklin Institute, entitled "Is Actinism a Species of Electrolysis?" Prof. Edwin J. Houston remarked that it was now generally known that differences of potential existed in the various parts of a growing plant. Little was, however, known about these phenomena, probably because such differences of potential could be brought about by so many different causes that those arising from one set of causes masked those produced by another set. The more important causes which produced differences of potential in growing plants were (1) the chemical processes that occurred in growing plants; (2) molecular movements of liquids throughout the plant; (3) chemical action of the various liquid materials exuded at the surfaces of injured plant tissue; (4) the evaporation of moisture from the surfaces of the leaves; (5) the electrolytic decomposition of carbonic acid, or the various forms which carbonic acid derivatives assumed during assimilation. Another and an external source of differences of potential was to be found in the differences of electric potential that generally existed between the atmosphere that surrounded the plant and the soil in which it grew. The oxygen which resulted during the general process of deoxidation, under the influence of sunlight, appeared to be evolved mainly from the non-illumined face of the leaf, and the carbon, utilised by the plant for the production of its woody fibre, was mainly liberated at or near the illumined face. Assuming these facts to be as above mentioned, the decomposition in the leaf under the action of sunlight, of the carbonic acid, or its derivative compounds, probably partook of the nature of electrolytic decomposition. In this direction Prof. Houston suggests several lines of investigation. Perhaps a suitable leaf-battery could be devised by connecting in alternate succession the opposite faces of a series of leaves on a plant-stalk. A comparison might be made of the effects of sunlight and artificial light on such electrolytic decompositions. Supposing the presence of the differences of electric potential, due to the electrolytic decomposition, to be established, and the direction of the electric currents so produced known, it might be useful to ascertain whether an electric current led through the plant in the same direction as the current produced by actinism would not tend to increase the assimilation and the subsequent growth of the plant; and whether, on the contrary, an electric current sent in the opposite direction through the growing leaf would not tend to act as a check. In a series of experiments concerning the effects of the electric light on plant growth, made at the Experimental Station of Agriculture of the Cornell University in 1889-90-91, some important facts were discovered concerning electric plant-culture. These experiments seemed to show that electric light promoted plant assimilation, and sometimes hastened plant growth. It would seem, says Prof. Houston, to be a matter of considerable interest in the case of these experiments to ascertain definitely whether any marked differences exist between the action of the light produced by a steady current and that produced by an alternating current. In the line of investigations here suggested it would, of course, seem as if the electric decomposition would be less marked in the case of the light produced by an alternating current than that produced by a steady current. And that, therefore, in those cases where the electric light of the steady current had proved to be injurious to the growth and assimilation of the plants, that with the alternating current light such injurious effects should be less marked.

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(Concluded from page 682, Vol. XXVIII.)

§ 81. **The Silver Voltameter.**—In the preceding paragraphs we have given a full account of the method adopted by Lord Rayleigh and Mrs. H. Sidgwick* for the measurement of the strength of a current. In order to determine the electro-chemical equivalent of silver, the amount of silver deposited by a known current has to be determined. We shall now proceed to explain how Lord Rayleigh determined the quantity of silver with very great accuracy.

The deposits were formed upon metallic basins (usually of platinum) charged with a neutral solution of pure silver nitrate. The bowls were prepared by careful clearing with nitric acid and distilled water, with subsequent heating. After being allowed to cool in a desiccator they were weighed to $\frac{1}{10}$ milligramme on a delicate balance with trustworthy weights. "The anode,† by which the current enters the voltameter, is formed of fine silver sheet, suspended by platinum wire in a horizontal position near the top of the solution. In order to protect the kathode from disintegrated silver, which in our experience is invariably formed upon the anode, the latter is wrapped round with pure filter paper, secured at the back with a little sealing-wax. This arrangement appears to us for several reasons preferable to the vertical suspension of the electrodes in the form of flat plates. In the latter arrangement the deposited metal usually aggregates itself upon the edges and corners of the

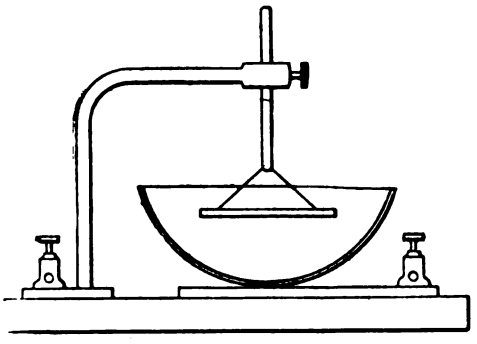

FIG. 56.—The platinum bowl rests by its own weight upon a copper plate connected with the binding screw on the right-hand side of the figure.

kathode with a tendency to looseness. Again, the solution rapidly loses its uniformity. At the kathode the solution becomes impoverished and at the anode it becomes concentrated. With vertical plates the strong solution soon collects itself at the bottom, and the weak solution at the top, so as to give rise to considerable variation of density. It is true that the horizontal position of the electrodes necessitates the use of a porous wrapping, which would increase the difficulty of determining the loss of weight at the anode. M. Mascart appears to have succeeded in determining this loss, but the disintegration which we have always met with rendered the attempt on our parts hopeless. It is possible that something may depend upon the mechanical condition of the metal, but as to this we cannot speak with confidence. The blackish powder left upon the anode has at first the appearance of being due to chemical impurity, but it occurs with anodes of the highest quality of silver and is completely soluble in nitric acid."

§ 82. **Effect of Silver Acetate.**—In the earlier part of his research Lord Rayleigh was much impressed with the importance of obtaining the deposit in a form sufficiently coherent to be proof against any risk of loss in the washing and subsequent manipulations. He found that the addition of a very small proportion of acetate of silver gave a much *better looking* deposit, which was less crystalline in appearance and of much closer texture than the deposit from pure silver nitrate. The apparent improvement led him to use solutions containing sensible amounts of acetate in nearly all the experiments carried out during the first year. Discrepancies, however, presented themselves of an amount much greater than had been expected, and they were of such a character as to show that the disturbing causes were to be sought in the behaviour of the voltameters, and not in the current-weighing apparatus. Thus it was found that the numbers obtained on the same occasion from the two voltameters in series, through which exactly the same quantity of electricity had passed, were liable to as great a disagreement as the numbers derived from experiments on different days. Lord Rayleigh made a laborious series of determinations with solutions containing more or less acetate, and for many months the results were fairly concordant, and were nearly taken as satisfactory. But on continuing the experiments with a fresh stock of solution (probably containing less acetate) a systematic change became apparent in the direction of smaller deposits. It had been thought that full precautions had been taken to secure adequate washing out of the silver salt from the deposit, and special experiments had proved that the weights were not appreciably changed by further washing with pure water, or by re-soaking in the depositing solution, with a second washing and drying like the first. A very careful attempt was made to test by analysis whether any of the silver nitrate was enclosed in the pores of the deposit; but the results of the analysis were felt not to be decisive, since the deficiency to be found in this way would correspond to only about one-third of the weight of salt actually present. The appearance of the deposits under the microscope was such as to suggest a doubt whether a complete elimination of the salt from the pores of the deposit was possible with any amount of washing. The diminution in the weight of the deposits in the later experiments, with a smaller amount of silver acetate present in the solution, might be attributed to a more complete washing out of the salt, rendered possible by the more open texture of the deposits. This encouraged Lord Rayleigh to test the behaviour of pure nitrate solutions.

"The result was a further small, but distinct, diminution in the weights, and we were now convinced that the use of acetate had been a great mistake, costing us six months' almost fruitless labour. When the deposits are taken upon the concave surface of a bowl they are coherent enough for convenient manipulation, without the aid of acetate. The danger of retention of salt or other impurity is far greater than of loss of metal, and this danger is aggravated by the acetate. Indeed, it would be scarcely too much to say that the danger is converted into a certainty, for from the fine pores of these deposits it seems almost impossible to remove the salt effectually."

§ 83. **Procedure with Silver Nitrate.**—In his later experiments, Lord Rayleigh used solutions containing only pure silver nitrate. He describes the solution usually employed as "a neutral 15 per cent. solution of pure silver nitrate." After the current had passed through the voltameter for from three-quarters of an hour to two hours, the platinum bowls were treated with hot and cold water and with alcohol. The bowls were passed backwards and forwards between cold and boiling distilled water. They were also soaked in alcohol, and then, while still wet with the liquid, plunged into boiling water. The object of this treatment was to produce as great a disturbance as possible within any pores that there might be in the deposited silver, and so to get rid of any silver nitrate which might be contained in them. The basins were then filled with

* "On the Electro-Chemical Equivalent of Silver," *Phil. Trans.* Roy. Soc., 1884.

† The terms *anode* and *cathode* are due to Faraday. Wishing to employ as names for the two surfaces, at which the current enters and leaves a decomposing body, terms which should distinguish one from the other, and at the same time should be free from all theory, he sought for a natural standard of electric direction, and found it in the earth. "If the magnetism of the earth be due to electric currents passing round it, the latter must be in a constant direction, which, according to the present usage of speech, would be from east to west, or, which will strengthen this help to the memory, that in which the sun appears to move. If in any case of electro-decomposition we consider the decomposing body as placed so that the current passing through it shall be in the same direction, and parallel to that supposed to exist in the earth, then the surfaces at which the electricity is passing into and out of the substance would have an invariable reference, and exhibit constantly the same relations of powers. Upon this notion we purpose calling that towards the east the *anode* (the way which the sun rises), and that towards the west the *cathode* (the way which the sun sets)."—*Exp. Res.*, § 663.

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water and allowed to stand over night, so as to give free play to diffusion. They were then rinsed a few times, and placed in an air closet to be dried at 160°C. After cooling in a desiccator they were carefully weighed.

It was felt, however, that there might still be some of the silver nitrate remaining among the pores of the deposit. This would be decomposed on heating to a red heat, the NO_3 of the salt being driven off. If the bowl is now weighed again, the loss of weight will represent the NO_3. If W. grammes is this loss of weight, the silver which will be left behind on the decomposition of the $AgNO_3$ will weigh W. 108/62 grammes. Thus, to get the true weight of the electrolytic deposit W. 108/62 grammes must be substracted from the weight of the bowl after heating to redness. In attempting to carry out this process Lord Rayleigh met with several difficulties. It was impossible without injury to the bowls to raise them to a red heat, since silver and platinum begin to alloy at that temperature. To overcome this difficulty Lord Rayleigh attempted to use *silver* bowls, but found that their weights did not remain constant when strongly heated, the variation being much larger than could be tolerated when the highest accuracy was desired. On the other hand, the *platinum* basins might be heated to redness without changing more than $\frac{1}{10}$ milligramme. It was therefore decided to use the *platinum* bowls, but not to raise them to quite a red heat when containing the silver deposits.

"An exposure for five minutes to a heat just short of redness does not seriously damage the basins, and appears to be nearly, if not quite, sufficient to drive off the last traces of NO_3. With a pure nitrate depositing solution, and with the treatment for elimination of the salt above described, there was sometimes no loss on heating, but perhaps more often the balance indicated a loss of one or two-tenths of a milligramme. With respect to the interpretation of this, it is difficult to say whether or not it ought to be regarded as due to traces of salt retained in spite of all the washings. If so the true weight of deposit is smaller still by nearly twice (108/62) the apparent loss; but it is very possible that there may be traces of grease liable to be burnt off at a red heat, so that the loss in question cannot with confidence be attributed to nitrate." The weights adopted for the silver deposits were those found after heating nearly to redness for about five minutes.

§ 84. **Silver Chlorate.**—In some of the experiments Lord Rayleigh used deposits from chlorate of silver. The chlorate was used in a nearly saturated 10 per cent. solution, and also in a 5 per cent. solution. ("The tendency to crystallise upon the anode is an objection to the use of the strong solution, and probably makes itself the more felt in consequence of the paper wrapping, which impedes the free circulation of the liquid.") Voltameters charged with silver nitrate were included in the same circuit, so that the comparison was made under the most favourable condition. "The results show an exceedingly good agreement, and constitute perhaps the most accurate verification which Faraday's 'Law of Electrolysis' has as yet received." The weights of the deposits from chlorate and nitrate did not usually differ from one another by more than two or three parts in ten thousand.

§ 85. **Effect of Copper.**—In the earlier experiments Lord Rayleigh used anodes containing an appreciable quantity of copper. The copper evidently tended to accumulate in the solution, becoming after a time apparent by its colour even when neutral; on addition of ammonia a distinct blue was struck. Lord Rayleigh desired to ascertain whether under these circumstances there was danger of the deposits becoming contaminated. A distinctly blue solution was prepared, in which the proportion of copper to silver was considerable, and a deposit made. The texture was very much modified by the action of the copper, and the appearance was such that it was difficult to believe that the weight could be more than a small fraction of that of the simultaneous deposit from a pure silver solution. Some of the metal which adhered very loosely was lost in the washing, but the weights agreed to within a few milligrammes. When the deposit was dissolved in nitric acid and supersaturated with ammonia, the solution showed no trace of colour, although about one part of copper in ten thousand can be detected in this way.

§ 86. **Practical Details.**—Lord Rayleigh found that when the current through the voltameter was weak (not exceeding $\frac{1}{4}$ ampere) there was considerable latitude in the strength of the silver nitrate solution, and even a four per cent. solution was found to give satisfactory results. But for stronger currents it is advisable to keep the strength of the solution up to 15 or 30 per cent. If the solution is too weak in relation to the density of the current, the deposit has a tendency to looseness, and is liable to grow up in an irregular manner so as to meet the anode. In a 3in. bowl such a solution will allow of a current of about one ampere for a period of an hour. The strongest solution that Lord Rayleigh was able to use with a single voltameter was about two amperes, and for that purpose he employed a solution containing one part of salt to two parts of water. The deposit would probably have deteriorated if the current had been allowed to flow for much longer than a quarter of an hour, but in that time an ample amount of deposit (two grammes) was obtained.

"The practical conclusion is that currents not exceeding $1\frac{1}{2}$ amperes may be conveniently measured in a 3in. voltameter by using a strong solution and stopping the operation after about a quarter of an hour. A shorter time than this would hardly allow of sufficiently precise measurement when a high degree of accuracy is aimed at. For purposes where an error of $\frac{1}{3}$ per cent. is admissible, a duration of five minutes would be sufficient, and under these circumstances a stronger current would be unobjectionable."

"It will be seen that the application of this method to the measurement of such currents as are usually passed through incandescent lamps presents no difficulty, and we hope that it may be generally adopted as a control upon the indications of instruments depending for their trustworthiness upon the constancy of springs or of steel magnets. The anodes should be composed of fine silver sheet (about $\frac{1}{8}$in. thick), such as is sold for five shillings per ounce, and should not be allowed to approach the sides of the bowl too closely. As there need be no waste of metal, the expense of silver as compared with copper should not be allowed to stand in the way of its use. For practical purposes it will be unnecessary to take some of the precautions which we thought incumbent upon us. After rinsing a few times with distilled water the deposit may be left to soak for an hour or so, and then, after another rinsing, dried over a spirit lamp. After the lapse of another hour it may be weighed with a risk of error not exceeding a few tenths of a milligramme."

When stronger currents are to be measured the silver voltameter is less convenient. Platinum bowls of large size are not usually met with, but two or three may be combined *in parallel* without much trouble. In one of Lord Rayleigh's experiments the same current was passed successively through a single voltameter, and then through two arranged in parallel. The deposit on the single bowl thrown down in 13 minutes was 2·2327 grammes. Those in the other bowls were 1·0114 and 1·2215, altogether 2·2329, agreeing almost precisely. In this way, with three bowls, such as Lord Rayleigh used, there would be no difficulty in measuring currents up to five amperes.

§ 87. **Calculation of the Results.**—From the theory of the current weigher we have, as in § 78, the following relation between the current i and the difference of weighings observed in air m,

$$i = \mu \sqrt{m},$$

where for Lord Rayleigh's current-weigher $\mu = 0{\cdot}037048$. If w be the electro-chemical equivalent of silver in C.-G.-S. measure, viz., the quantity of silver in grammes deposited per second by the unit C.-G.-S. current, then the rate of deposit of silver by the current i is $w\,i$ or $w\,\mu\,\sqrt{m}$. In the table of results Lord Rayleigh gives a list of the values of the quantity $\sqrt{m}$/ (deposit per second) found in the separate experiments. The mean value of this quantity was 2414·45.

But

$$w = (\text{deposit per second}) \times \mu \sqrt{m}$$

so that

$$w = \frac{1}{2414{\cdot}45 \times 0{\cdot}037048} = 0{\cdot}0111794$$

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In practical units the amount of silver in grammes deposited per ampere per hour is 4·0246. Lord Rayleigh quotes the two following results for the electro-chemical equivalent of silver :—

Kohlrausch, 0·011183.
Mascart, 0·011156.

§ 88. **Conclusion.**—I have now arrived at the end of my account of the careful and accurate research of Lord Rayleigh and Mrs. Sidgwick. In the earlier part of the series of articles I explained the principles on which the current-weigher works, and the methods employed in the calculation of its constants. In the last few paragraphs I have given an account of the treatment of the silver deposited, and in this part I have quoted many passages from Lord Rayleigh's memoir, since I felt that it would be very difficult to express the facts in language clearer and more concise than that employed by Lord Rayleigh.

It has been represented to me that the portions of the articles dealing with electrodynamics would be useful to students and others. I hope that these portions, together with some additions, may be republished in the shape of a book, so as to form a sort of sketch of electrodynamics. I should, therefore, be grateful for any corrections or suggestions which any of my readers might send to me at the Cavendish Laboratory, Cambridge.

I ought to add that Mr. Glazebrook has pointed out to me that some of the reasoning of § 38 is not quite sound. This I shall hope to correct in the book. I believe, however, that the arguments of the succeeding paragraphs are unaffected by this error.

AMPERE-CENTIMETRE, A MEASURE OF ELECTRO-MAGNETISM.*

BY CARL HERING.

It appears from the following deductions that an electric current multiplied by the length of the circuit will represent the number of magnetic lines of force generated by this current, or, in other words, that the number of lines of force generated by a current can be measured by the product of the current and the length of its circuit. A unit current passing through a unit length of circuit appears to generate a certain fixed and constant number of lines of force. This, of course, has reference to the electro-magnetism of the current itself, and does not include the influence of any magnetic bodies in the neighbourhood.

First of all it is necessary to show that amperes multiplied by length will give a unit of a similar nature to magnetic lines of force or flux, in order to show that an equivalent between the two may be given without transgressing the laws of physics. This may be shown conclusively by the aid of the dimension of these units in the absolute system. The dimension of current is $m^{\frac{1}{2}}\ l^{\frac{1}{2}}\ t^{-1}$, while that of magnetic flux (that is, number of lines of force, not their density per square centimetre usually represented by H or B, nor the intensity, as it is sometimes called), is $m^{\frac{1}{2}}\ l^{3-\frac{1}{2}}\ t^{-1}$. It will be seen that the former multiplied by a *length* gives the latter. This shows conclusively that ampere-centimetres, or ampere-feet and magnetic flux are units, of the same kind and can therefore be equated.

Having determined this point the following appears to show that every unit length of a circuit conveying one ampere generates a fixed and constant number of lines of force. Using absolute units, the intensity of magnetisation (or number of lines per square centimetre) at the centre of a circle of one turn, according to the well-known formula, is

$$H = \frac{2c\pi}{r}$$

in which r is the radius in centimetres and c is the current.

Now, the intensity of the field is different in different parts of the area enclosed by the circle, being greatest nearest to the wire, but it may be assumed that in all circles, large or small, the ratio of the intensity at the centre, to the average intensity in the whole circle, is a constant. Let this ratio be called K, then the total number of lines will be equal to the intensity at the centre multiplied by the area, and by K ; that is

$$M = \frac{2c\pi}{r} \times \pi r^2 \times K = 2c\pi^2 rK$$

* A Paper read at the Electrical Section of the Franklin Institute.

Dividing this by the circumference will give the number of lines per unit length of the circuit

$$2c\pi^2 rK \div 2\pi r = C\pi K$$

or per unit of current, this is equal to πK. It will be seen that this is a constant and is *independent of the radius r*. This means that the number of lines per unit length and per unit current is the same for all circles, and therefore also for a straight line, which is a circle of infinite radius.

From this it appears that, knowing this constant number of lines per ampere per centimetre or foot, the calculation of the total number of lines generated by any circuit or coil would merely be the product of the current, the length of the circuit, and a constant.

It should be remembered, however, that this deduction supposes theoretical conditions ; that is, in a filamentary wire having no appreciable diameter. How far the size of the wire introduces an error remains to be determined. At all events, if the diameter of the wire is small, is compared with the diameter of the coil, and specially if the coil, as it usually does in practice, contains iron which appears to concentrate the lines in it, and therefore probably attracts those circulating in the body of the wire itself, it may, doubtless, be assumed that the ratio of the flux in two coils would be equal to the ratio of their ampere feet, which proportion might be of use in dynamo construction.

The above deductions were made by the writer a number of years ago, but as they did not appear to agree with some existing laws at that time, the matter was laid aside. It seems, however, that subsequently some dynamo builders have advocated and used this system of calculation in preference to the other; and it was therefore thought best to publish this proof, hoping that some others, well informed on this subject, might point out the discrepancies, if any, and perhaps show the extent of the application in practice of calculating the magnetic flux of a current from the ampere-centimetres of the circuit.

[The following argument shows that Mr. Hering's contention is only true when certain conditions are fulfilled. Let A be the current in amperes flowing through a magnetising coil of n convolutions. Let B be the density of the lines of force in the core whose permeability is μ. Let the length of the magnetic circuit (supposed closed) be l. Then

$$\frac{4\pi n A}{10} = \frac{B}{\mu} l.$$

The total number of lines flowing through the iron core is N where

$$N = B \times \pi r^2,$$

r being the radius of the iron core. If L is the length of the magnetising coil, $L = n \times 2\pi r$.
From these equations we find

$$N = \frac{\pi r^2 \mu}{l} \cdot \frac{4\pi n A}{10} = L A \times \frac{2\pi r}{10 l} \mu,$$

so that N will only be proportional to L A (the number of amperes × by the length of the magnetising coil), provided

$$\frac{r}{l} \mu$$

is constant.

Mr. Hering's statement is, therefore, only true for closed magnetic circuits whose dimensions bear a constant proportion to one another, and the iron of which is magnetised to the same state of saturation, so as to have constant permeability. We allude further to this matter in our Notes column.—Ed. *E.*]

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, June 3rd.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Metallic Carbonyls." By Ludwig Mond, F.R.S.

FRIDAY, June 10th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1.) "Some Points connected with the Electromotive Force of Secondary Batteries." By J. H. Gladstone and W. Hibbert. (2.) "Workshop Ballistic and other Shielded Galvanometers." By Prof. W. E. Ayrton and T. Mather.

ROYAL INSTITUTION.

9 p.m. Evening Discourse : "Magnetic Properties of Liquid Oxygen." By Prof. Dewar, F.R.S.

MONDAY, June 13th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

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THE TELEPHONE AND ELECTRIC TRACTION.

In the early months of 1889, when the Court of Appeal had given judgment in favour of the EDISON lamp patent and against the transformer patent of GAULARD and GIBBS, there were individuals sufficiently sanguine to prognosticate that the barren era of litigation was at an end, and that electrical engineers would ere long be far too busy building dynamos, laying mains, and advising town councils, to trouble their heads about "master" patents, however musty. And for a time everything pointed to the fulfilment of this pleasant prophecy. Applications for Electric Lighting Provisional Orders were as plentiful as blackberries; the Metropolis was divided into areas which looked extremely attractive on a properly coloured map, and the lucky allottees of these districts together with a few provincial concerns settled down to serious work. But all this was too Arcadian to last. Big as the "boom" was, it did not afford occupation for everyone. Mischief, if not work, we know is always found for idle hands to do, and to this fact, perhaps, as much as to any other, must be attributed the recent recrudescence of patent and other litigation. First one and then another ancient catalogue of claims has been unearthed; and at the present moment the central-station business alone, with the LANE FOX case only just on the list of Appeal Court II., is threatened by both the three-wire and the "feeder" men. The legal harvest, prospective and actual, is indeed a fine one; and to maintain it for some little time to come at its present high average the telephone companies, after having in a more or less subterranean manner persistently harassed the heavy electrical engineering industry, have now apparently made up their corporate minds to a policy which

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may be summed up in three words, "Place aux téléphones." When we mention that at Bournemouth the supply of electricity is in no little danger of being summarily suspended owing to the action of the Western Counties and South Wales Telephone Company, that both the Thomson-Houston line at Leeds and the South Staffordshire Tramways are threatened with injunctions, and that it is sought to secure the insertion in the Blackpool Improvement Bill of the one-sided "Birkenhead" telephone protection clause, we think it will be generally agreed that the interference of the telephone companies with the development of the rest of the electrical industry "has increased, is increasing, and ought to be diminished."

American law is not English law; neither are the decisions of the Supreme Court of Ohio likely to carry much weight in Fleet-street; nevertheless, a brief glance at what has occurred across the Atlantic may provide potential litigants on this side both with arguments and encouragement. Writing under date May 11, 1889, our New York correspondent stated that there was considerable agitation on the part of the telephone companies in favour of compelling the electric railways to run complete metallic circuits. As agitation of this kind generally spells litigation, we have two months later the first legal decision on the question of whether traction or telephone companies were to double their wires. At the end of July it was decided at Chattanooga (Tennessee) that an injunction which had been obtained against the street railway of that cacophonous city should be dissolved, but that the railway people should be bound over to pay compensation in the event of their operations damaging the property of the telephone company. In contrast to this somewhat hesitating judgment we have about a year later the very emphatic and common-sense pronouncement of Chancellor Henry R. Gibson, in the action brought by the East Tennessee Telephone Company against the Knoxville Street Railroad Company. The telephone argument was that both companies could not use "earth" simultaneously, as the telephone current was "too delicate to contend with the railroad current," and that, as the telephone company had "a vested right to the exclusive use of the earth and the air as against every person using the same for electrical purposes," an injunction should issue. Chancellor Gibson, however, failed to see how the simple privilege of erecting poles along the kerb could be magnified into a grant of "the exclusive use of every inch of ground within the corporate limits for all the purposes of an earth circuit for electricity," and held that the Knoxville Street Railroad Company had the right to propel its cars by any system authorised by the municipality. Similar judgments were given at Albany, N.Y., and Lafayette, Ind.; and finally, on June 2, 1891, the Supreme Court of Ohio, in the action brought by the City and Suburban Telegraph Company against the Cincinnati Inclined Plane Railroad Company, held that the streets were primarily intended for the general traffic purposes of the public; and the fact of the motive power which facilitated that object being changed into something which interfered with a subordinate use of the highway ought not to make any difference. In Germany also, where the telephones are under the State, the Courts have held that the streets are properly used for locomotive purposes, and that nothing else using the streets incidentally should be allowed to interfere with locomotion.

In England we first heard of telephone opposition in connection with a proposed electric tramway at Weston-super-Mare. The next case which excited attention was that of the Wellingborough and District Tramroads Bill, the promoters of which, while forced to bear the expense of protecting the then existing lines of the South of England Telephone Company, were only rendered liable in regard to telephone circuits subsequently erected, if it could be shown that reasonable and proper precautions had been taken to insulate and protect them. But the most complete victory scored by the telephone interest was in July, 1890, in connection with the Birkenhead Electric Lighting Provisional Order Bill. A clause was inserted which obliged the undertakers to construct and work their entire system in such a manner as not to injuriously affect existing or *in futuro* telephone circuits. The wicked machinations of the telephonists have, it will thus be seen, been as uniformly successful in England as they have been the reverse in America. The reason is not far to seek. The National Telephone Company has spared neither pains nor expense in presenting its case; the electricity supply companies, badgered by Vestries, County Councils, and the Board of Trade, regarded one more clause-inserter with comparative indifference. Now that a municipal Bill has been interfered with and a supply company brought into court we may expect to see the tables turned.

The position of the telephone companies is indeed inherently weak. They undoubtedly render a great public service, but electric railways are destined to render a still greater. They certainly employ a most marvellous, ingenious, and delicate instrument, but that is no reason for connecting it to what has been termed an electrical cesspool. The advent of electric traction has not introduced a totally new condition of affairs; it merely threatens to convert an irritating nuisance into one that is intolerable. It is of no avail to urge that complete metallic telephone circuits are not to be thought of, because they already exist and are likely shortly to increase; moreover, the Treasury Minute, which we print in another column, runs as follows:—"It will be a condition of any licence to a new company that their system must be constructed entirely of twin wires on metallic circuits, so that there may be an assurance of its efficiency." To oblige electric railways to employ complete metallic circuits is to impose mechanical and other difficulties upon them approximating the impossible. On the other hand, no telephone now entering the field—apart altogether from electric traction considerations or Treasury edicts—would dream of running anything but complete metallic circuits. The mistakes of telephone pioneers in the past cannot be permitted to be a bar to electrical progress or an excuse for incomplete work to-day and improper construction in the future.

A NEW ERA FOR THE TELEPHONE.

No more important events have occurred in the history of the State Telegraphs during the past two-and-twenty years than those which were signalised by the Telegraphs Bill introduced into the House of Commons last week, and by the Treasury Minute, dated 23rd ultimo, and published in the newspapers last Monday morning. That the Post Office was seriously thinking of putting an end to telephonic competition with the telegraphs, so far as the trunk wire system is concerned, we had been led to expect by recent utterances of the Postmaster-General; but that a scheme of such magnitude and completeness had been prepared, and was ripe for promulgation, will be a surprise to most people, and an astonishment to many. We have now for the first time an official declaration—or what may be termed a confession—of what has been suspected for many years past, that the Telephone Companies were materially diminishing the revenue which normally belonged to the State Telegraphs; in other words, that the business which

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the country bought and paid for was being rapidly diverted into private channels by the simple process of calling it by another name. The announcement will be useful if only to remind the country once again that the telephone is a telegraph, and that permission to work the younger system was merely provisional, and subject to its non-interference with the business of the older concern. To those who contended that the telephone, even as worked in this country, would serve as a feeder to the telegraph, and would, in fact, increase the earnings of the Post Office, this Treasury Minute is a decisive answer. In its earlier stage of growth it may be questioned whether the telephone did that; and certainly in its latest development it has done the reverse of that by diminishing the number of telegrams, just as has been the result of every conversation by telephone over the Government wires to Paris. The spread of the "trunk wire" system left no room to doubt the inevitable result; and as the extension of those lines could not in justice to the public interests be forbidden there remained no alternative but to acquire them and work them as part of the telegraph system proper.

It can hardly be said that the Government have got the best of the bargain. We are by no means convinced that the trunk wires can be worked for conversation purposes at a profit with the low tariff set forth in the Treasury Minute. Their acquisition may be regarded simply as an act of self-defence. If the wires prove unremunerative their extension will rest with the Post Office; and they can always be utilised telegraphically if not fully occupied telephonically. This is an advantage which no private telephone company could enjoy; and we think the inventors of the so-called "trunk wire" system of telephony may congratulate themselves on having forced the hands of the Government, and relieved their more legitimate business of a questionable and risky encumbrance. We have heard of freaks in the vegetable world which are technically described as the roots growing upwards and the leaves downwards. It was reserved for a modern telephone company to grow branches first and then to plant the trunks. The process is like constructing a railroad on the strength of a licence for a hackney carriage. The experiment could end only in one way.

As to the details of the new scheme under which the Post Office will take charge of all the main line wires, and permit connections to be made between their offices and the exchanges of the Telephone Companies, we must refer our readers to the Minute itself, which will be found in another column. On one or two points only can we find space to comment at present. It is expressly stated, and with very excellent reasons, that to the success of the scheme "united action on the part of the companies and the Post Office is necessary." There must indeed be friendly co-operation of a very ungrudging kind to assure for it any lasting success. Some of the conditions appear to put these friendly relations to a rather severe test. For example, the restriction as to written communications is removed, but the Post Office alone may deliver them. This is consistent with the rights of the Post Office; but it falls rather hard on the companies, and will prove expensive to the Government, who will have to bear the heaviest items of expense, namely for transcribing and delivering. Again, it is laid down that the whole trunk system shall be open to the public generally, and not to subscribers of the companies only. This, at all events, so far as post offices are concerned. On strict principles no exception can be taken to the enfranchisement of the general public; but it must operate to the disadvantage of the companies, and may lead to friction. On the other hand, the prospective admission of call offices in premises occupied by the Post Office will be a great boon to the companies; and the scale of commission for work passing between the telephone and telegraph systems appears to be on a fairly liberal footing. The charge for rental along railways, canals, &c., over which the Post Office have exclusive right, is reduced from 20s. to a nominal sum of 1s. per mile—a concession which does not count for much, however, now that the erection of trunk wires by the companies will cease. The royalties paid by the companies at present remain unchanged; but the Government in their Bill, an abstract of which will be found in another column, propose to assist in obtaining greater powers for the connection of exchanges by wires over private property. So far as the public are concerned the charges authorised by the Treasury ought to be well received. Our own misgivings are that they cannot be made remunerative, and that sooner or later the whole telephonic system will have to be reviewed, and finally transferred to the State; but that meanwhile the State will sustain a loss by partial acquisition, and the companies gain nothing by it. Should this prove to be the case the co-operation of both parties in the interests of the public, upon which so much stress is rightly laid in the Treasury Minute, though greatly to be desired, can hardly be expected.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

We regret that owing to the interference of the Council or the Institution of Electrical Engineers, or of a committee of that body, with our reporting arrangements, we are unable to present to our readers an abstract of the discussion which closed the last meeting of the Institution before the recess. As soon as we heard a rumour that the "Authorised Abstracts" were to be discontinued, we made, on April 8th, several suggestions through the Secretary, with the view of giving our readers an account of the discussions in the most useful form. Although ready to send our own reporter as formerly, we made, to avoid having the work done twice over, the proposition that we should contribute to the reporting expenses of the Institution at the usual rate per column, and receive in return an early type-written copy of the verbatim report, of which report we proposed to make a careful abstract, sending out proofs to the separate speakers. To these and other suggestions we received a courteous reply from the Secretary, dated April 11th, promising to submit the proposals to the Council at their next meeting, but intimating pretty clearly that there was not much chance of the Council acceding to them. Whether the Council, or their "editing committee," took six weeks to consider the question, forgot all about it, or thought we could wait, we do not know; but meanwhile the meetings continued, and, by way of getting something done, we inquired at the office of the Institution for the name and address of the official reporter, and arranged with him for a copy of the verbatim report. Our self-imposed task of abstracting, partially re-writing and condensing the discussion, sending out proofs to speakers, and marking those with an asterisk which were returned corrected, was no light one, but we ventured to think that it was worth doing. Only those who have taken part in these discussions are aware of the errors which must occur even in the most careful reporting of such highly technical matter, and of the importance of correction of the reports before publication, either by someone present at the meeting and versed in the subject, or by the speaker himself.

On May 25th we were at length informed that the Council hoped to be able to make arrangements for meeting our views, and a type-written copy of the reporter's notes of the last meeting was promised for Monday morning last. To this we immediately replied that we had been obliged to make our own arrangements, which were satisfactory, and which therefore we did not see any reason for disturbing. It appears that after our offer to contribute to reporting expenses and the full statement of our wishes, after obtaining the name of the reporter, in order to preserve the continuity of the reports

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while the Council were making up their minds, they, without giving us any notice, intimation, or reason for their arbitrary action, ordered the reporter to desist from supplying us with copies of his notes. We only heard from him on Monday last, and on inquiry on Tuesday morning, found that the type-written copies mentioned had been exhausted, and that there was no other copy in existence.

We have set out these details in full, not to justify ourselves, but to give our readers some idea of the way in which the minor affairs of the Institution of Electrical Engineers are managed or rather mismanaged. There is probably no other scientific society in London or the rest of the country, the Council of which exhibits so much indecision and inconsistency in its procedure. There is surely none of twenty years' standing which either has not come to some definite decision about the publication of its proceedings, or could not do so in a fortnight. An editing committee has always been a feature of the Institution; the first volume was published in 1873 under the supervision of such a body. Whoever the members of this committee may be, we would rather serve our readers independently of them; for our endeavours to carry out the spirit as well as the letter of their edicts to the best of our ability, fail to satisfy that body. The publication of the discussions is appreciated, we believe, by our readers in all parts of the world, and it would be a pity if these debates were buried, as is done elsewhere, in the ponderous unread volumes of a Society's Journal. We hope that by next autumn some sensible measures may be adopted.

THE PATIN ALTERNATOR.

This high-pressure alternate-current machine recalls at first glance, says *l'Industrie Electrique*, the dynamo designed some ten years ago by M. Anatole Gérard; a machine which stopped at the projected stage, the need for large output alternators not being felt at that date. There are, however, in reality several points of difference. M. Patin's machine has rotating field-magnets and a fixed armature. It takes the place of a steam-engine fly-wheel, or it can be mounted direct on to the shaft of a turbine. This new arrangement has the double advantage of doing away with rope or belt transmission, which absorbs mechanical power and demands constant attention, and of reducing to a large extent the space occupied by machinery. Until now all direct coupled machines demanded angular velocities, which rendered necessary a recourse to high-speed steam engines, consuming a great deal of steam, and quickly wearing out. M. Patin's dynamo has been designed for coupling direct to Corliss engines or others of the same type, having a high efficiency and a small angular velocity.

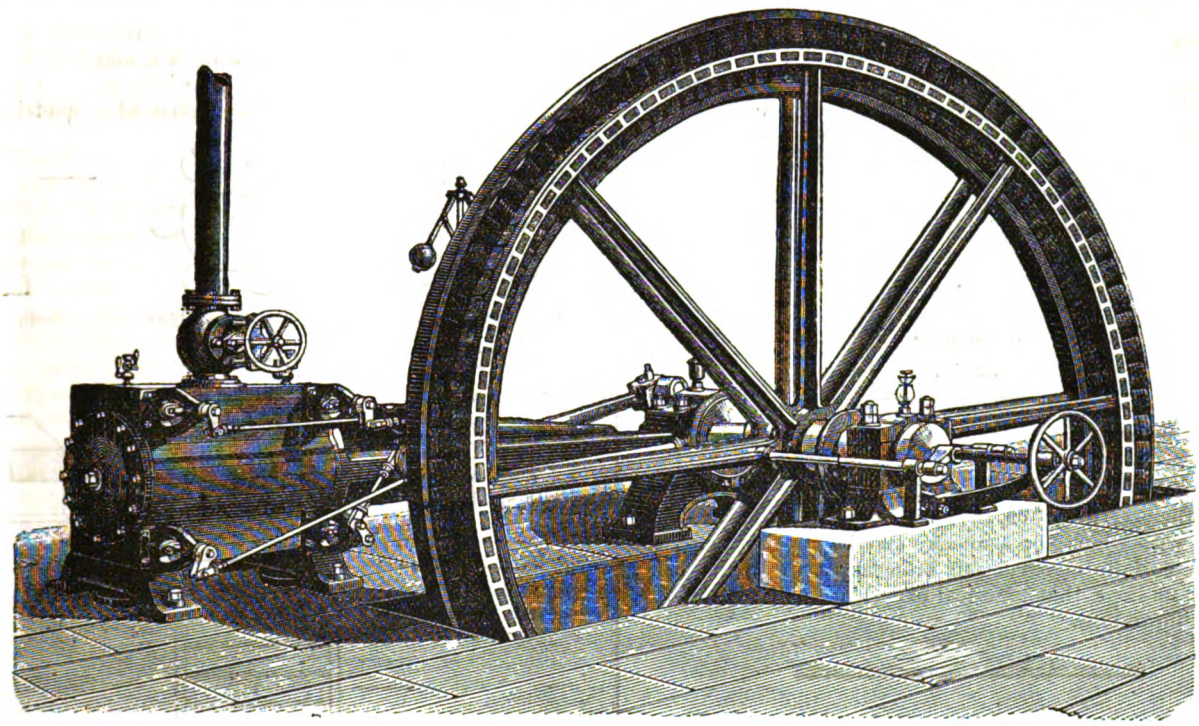

Fig. 1.—Patin 75-kilowatt Alternator.

The rotating field-magnet is mounted on the engine shaft and acts as its fly-wheel. It consists of two cast-iron rings (*see* Fig. 1) carrying soft iron pole-pieces recessed into it. The inner ring forms part of the fly-wheel itself, and the outer ring is joined to it by means of special arms as shown in Fig. 2. The fixed armature can be moved laterally for examining and quickly replacing coils in case of accident. The armature coils, which are composed of flat strips of copper and are wound on a frame of cast copper, have an arched shape, like the annular cylindrical space in which they are fixed. They are kept in position by bronze stirrups, bedded in the armature core with a special cement. (Fig. 2.) The displacement of the armature is effected by means of a screw actuated by a hand wheel placed near a bracket, and communicating its motion to two cross-pieces, which are solid with the armature core. Two insulated copper rings mounted on the dynamo spindle

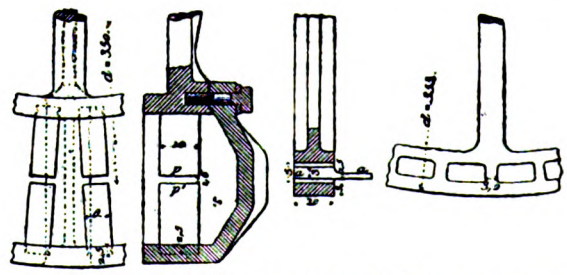

Fig. 2.—Details of rotating field-magnet and of fixed armature of Patin 40-kilowatt Alternator.

are connected up to the ends of the field-magnet coils; the exciting current from a special dynamo (sometimes distinct, sometimes arranged on a prolongation of the shaft) being brought to the rings through two rubbing contacts.

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Figs. 2 and 3 relate to a 40-kilowatt machine. Fig. 1 is a perspective view of a 75-kilowatt alternator, of which the following are the principal data :—

Number of field-magnet poles	76.
Electromotive force	2,400 volts.
Current	31 amperes.
*Peripheral speed	14·66 metres per second.
Armature resistance	0·75 ohm.
Length of wire on armature	520 metres.
Section	3 sq. mm.
Excitation losses	2,500 watts.
Armature losses	730 watts.
Electrical efficiency	96 per cent.

* 2,886ft. per minute.

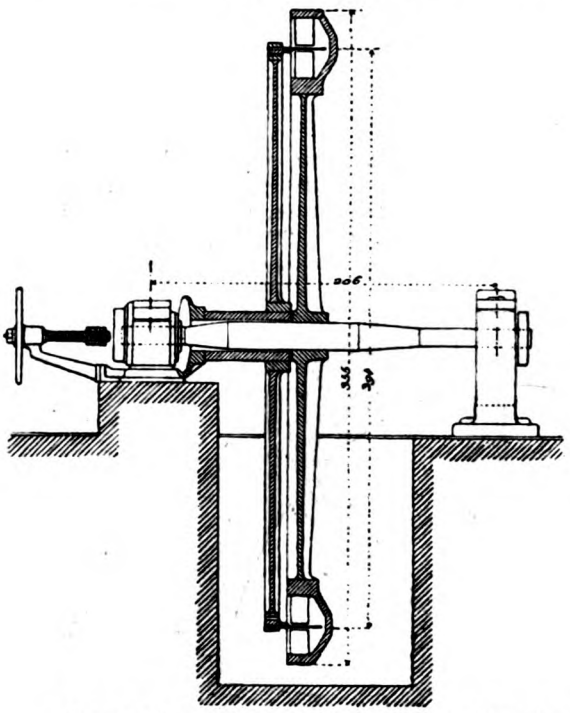


Fig. 3.—Cross-section of Patin 40-kilowatt Alternator.

The arrangements adopted by M. Patin in his new alternator commend themselves to us, says *l'Industrie Électrique*, owing to the ease with which the armature can be repaired, and the simplification of its construction brought about by its being fixed. Let us hope that practical experience will confirm this favourable impression.

A PORTABLE INSTRUMENT FOR MEASURING THE STRENGTH OF MAGNETIC FIELDS, WITH SOME REMARKS ON THE STRAY FIELDS OF DYNAMOS.

BY EDWIN EDSER AND HERBERT STANSFIELD.

The instrument which was briefly described in our report of the recent meeting of the Physical Society was designed to give direct readings for the strength of magnetic fields, in order to obviate the difficulties, sometimes practically insuperable, attending the ballistic method. Portability, a fair degree of accuracy, and a wide range were the qualities sought. The instrument as now constructed has an error of only about two per cent., is both small and light, and can be used to measure any fields from two or three lines per sq. cm. upwards. The only accessories required are a resistance box and a dry cell, or other source of a constant E.M.F.

The principle of the instrument is the inversion of that of the d'Arsonval galvanometer ;* the torque necessary to restore a small coil through which a current circulates to its initial position parallel to the lines of force, being a measure of the strength of the field at the position of the coil.

* The same principle has been used by Messrs. Siemens and Halske in some investigations on the rotary current motor. See *Electrical Review*, June 15, 1891.

A section of the instrument is shown in Fig. 1. A B is a small coil, wound of 44 B.W.G. wire, to 50 ohms resistance, half is attached to each side of a small sheet of mica, C D, to which a small pointer C is attached, which moves over a scale, to

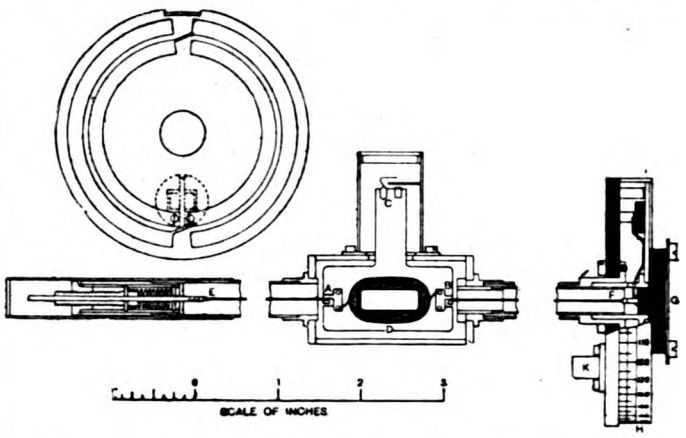
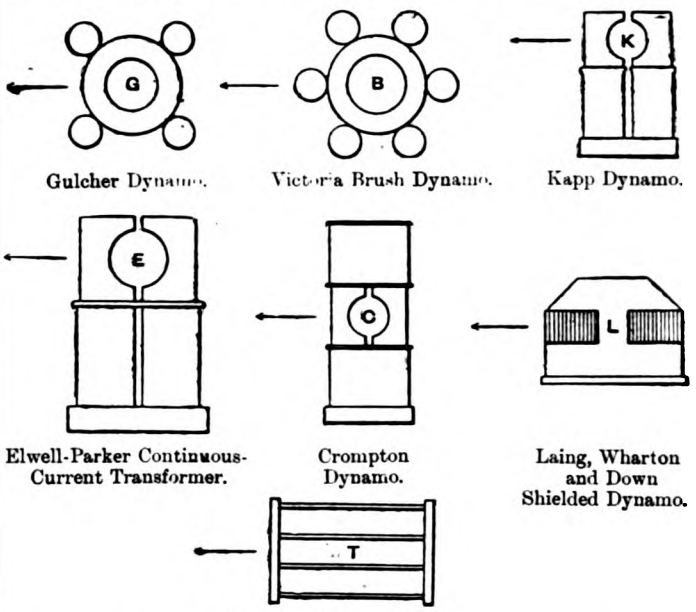
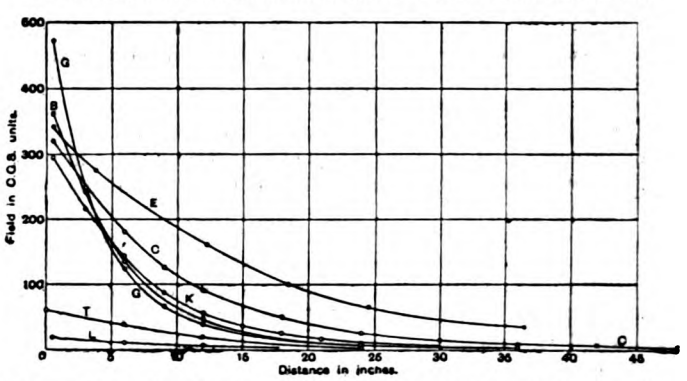


Fig. 1.—Sectional view of Edser and Stansfield's instrument for measuring magnetic fields ; with enlarged view of circular commutator.

indicate the position of the coil. The suspension consists of two fine strips of German silver wire, A E and B F, which also serve to carry the current to and from the coil. A E is connected at E (by means of a special form of geometrical slide,



The arrows show the direction in which the various measurements were made.



Curve showing decrease in strength of stray magnetic fields at various distances from the dynamo.

Fig. 2.

designed to combine a spring suspension and an adjustment for torsion), with the case of the instrument ; B F is insulated at F from the case by a block of ebonite F G, clamped to a

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graduated torsion head H I. The coil is approximately balanced, but in order to eliminate any errors due to want of balance, a commutator is enclosed within the torsion head, by means of which readings can be taken on either side of the zero. This commutator is so constructed that on turning the torsion head the current is sent in one direction through the coil, this direction being reversed on reversing the direction of the torsion. K is a plug contact for connecting to the battery used.

For a source of current a Hellesen dry cell has been used, the E.M.F. on a circuit of 50 ohms being practically constant over a longer period of time than that required for an experiment.

To vary the sensitiveness of the instrument, a resistance box is connected up in series with the battery and instrument. Thus, the resistance due to the instrument being 50 ohms,* if F be the field corresponding to any given degree of torsion with no external resistance, the field corresponding to the same torsion, with $n \times 50$ ohms external resistance, will be $(n+1)$ F.

The constant of the instrument was determined by finding the torque necessary to restore the coil to its initial position parallel to the lines of force, in the uniform field between the coils of a Gaugain pattern galvanometer, through which a known current circulated. In using the instrument, the direction of the field at any point is first determined by means of a small pilot needle; the instrument, joined up through the resistance box with the cell, is then placed so that the axis of the coil and the axis of suspension are at right angles to the lines of force, and the torsion head is turned till the small pointer C is brought to the zero of the scale over which it moves. The reading of the torsion head being taken, the operation is repeated on the other side of the zero.

If θ = mean of these two readings.
n = multiple of 50 ohms external resistance.
C = constant of instrument.
Field = $C(n+1)\theta$.

By permission of the Committee of Experts, and of the various firms exhibiting, a number of measurements have been made at the Crystal Palace Electrical Exhibition, some of the results of which are embodied in Fig. 2. These curves show the strength of field at various distances from the different types of dynamos. It is noticeable that in the multipolar machines (B and G, Fig. 2) the strength of stray field falls off much more rapidly than in the bipolar types.

Mr. Harrison having kindly lent a watch with a brass balance-wheel for testing purposes, it was determined that a field of 10 C.-G.-S. units did not materially affect its rate, but that a field of 40 C.-G.-S. lines entirely upset its working. This would tend to show that at 3ft. from a dynamo injurious effects may be apprehended.

ON THE CAUSE OF THE CHANGES OF ELECTROMOTIVE FORCE IN SECONDARY BATTERIES.

The following is an abstract of the Discussion on the above Paper, which was read before the Institution of Electrical Engineers, on May 12th and 19th, by Messrs. Gladstone and Hibbert:—

* Abstract revised by speakers.

THURSDAY, MAY 19TH.

*Mr. G. H. ROBERTSON, speaking in Prof. Armstrong's name as well as in his own, said that Messrs. Gladstone and Hibbert's Paper was undoubtedly an important contribution to the discussion of a very complex and difficult problem; but the verdict on it, he thought, must be one of "non-proven," as indeed Prof. Armstrong and himself were ready to admit was the case as regarded their own recent attempt to display the inner working of the lead-sulphuric-acid lead peroxide cell. While accepting the results, he must decline at present to accept the author's interpretation of them; indeed, he thought, Prof. Armstrong and himself were justified in claiming them in support of the explanation they had advanced in their Royal Society Papers, which it seemed the authors in a measure sought to traverse. Divested of all details, the contention of Messrs. Gladstone and Hibbert appeared to be, that practically action was limited to the occurrence of the series of interchanges pictured by the equation—

$$Pb \,\Big|\, \underset{aq}{SO_4H_2} \,\Big|\, \underset{aq}{\overset{}{\overset{}{\overset{

ceivable that such a counter-electromotive force might exist; moreover, there was the possible influence of the lead support to be considered. Further consideration of the matter has since led them more and more to favour the view that a considerable counter electromotive force was operative throughout discharge, which was conditioned by the "peroxide" in solution at the lead peroxide plate. Its presence could not be denied; and if present it would seem that it must be operative. The explanation that they should give of the variations observed by the authors would be obvious from these remarks.

*Mr. CROMPTON thought the Paper a valuable contribution to the science of the subject Some six years ago Mr. Howell and himself had taken out a patent to introduce artificial means for circulation, in order to equalise the strength of the acid throughout the cell. They had utilised the increase in the resistance of H_2SO_4 when its density varied above or below that of a 30 per cent. solution to make the electrolyte self-regulating as regards its density. Any increase or decrease of specific gravity having the same effect of increasing the resistance of the electrolyte, a little thought would show that this property was of the highest importance, as any change in specific gravity would have the tendency of producing the compensating effect of decreasing or increasing the action at that particular point. Although his coadjutors and himself hailed the results obtained by such workers as Dr. Gladstone, Prof. Ayrton, Mr. Robertson, and others as of the greatest interest, yet they looked on the results with a certain amount of suspicion. The actions in an accumulator were so very complicated and so very difficult to follow, that he would hesitate to accept Dr. Gladstone's theories as proved until they had stood the test of a much longer series of experiments, and under wider conditions than those detailed in the Paper. Many results which he (Mr. Crompton) had appeared to arrive at after experiments on small cells had been absolutely contradicted by subsequent experiments with bigger plates and larger cells. For that reason he was one of those who believed that no quantitative experiments were of the least value until they had extended over some years. Mr. Howell, Mr. Clauss, and himself had been for six or seven years on the job. They could not introduce any means of artificial agitation, and it therefore became necessary to so proportion the spaces between the plates that the greatest freedom to circulation was given. After very long quantitative experiments they had arrived at the conclusion that the space occupied by the electrolyte between the plates must be nearly twice that occupied by the plates themselves. Again, the weaker the plates were mechanically up to a certain point, the stronger they were chemically. After many years they had fixed on a size of crystal which had given good results. His spongy lead was very spongy on the negative side, and it was of great importance to know at what strength of electrolyte the delicate crystals would be attacked by the electrolyte itself. At ordinary temperatures, that was under 75° F., he found that the critical density was 1,250 or 1,260. He wondered if Dr. Gladstone would be able to account for the very curious fact that in all the cells he (Mr. Crompton) had experimented with there was always a slight rise of electromotive force after the first rapid fall shortly after the commencement of discharge. He wished to call attention to a foreign contribution to the subject which ought to be read. That was a Paper contributed to the *Elektrotechnische Zeitschrift* of January 8th by Dr. Krügel, in which he pointed out the cause of that bugbear of all accumulator users, the self-discharge of negative plates under certain conditions. Dr. Krügel attributed it entirely to metallic impurities originally present in the electrolyte. Up to a very late period of the discharge the greater proportion of those impurities still remained on the lead plate, and it was only at a particular moment, almost the moment of reversal, that they got them in solution and were able to detect them.

*Mr. E. W. SMITH said that the first point he wished to call attention to was that in the Edinburgh Paper attention was called to the fact that after rest the potential difference rose when a discharge commenced. Another point was the decay of the positive grid. He did not think it was due to the formation of the sub-sulphate Dr. Gladstone mentioned. The cause of it was to be sought in the negative plate. If, as Dr. Gladstone pointed out, there was a considerable amount of local action on the positive grid at the end of charge during rest, should there not be a great deal more during the charge itself, when the sulphuric acid was of great density there? The author's hypothesis as to the substance which might be formed on acid strength next the plates becoming very low was not borne out by the facts. Dr. Gladstone mentioned the fact that on trying to calculate the electromotive force from thermo-chemical data he did not get results which agreed with his experiments. Now, the Edinburgh Paper showed, and Prof. Duncan also showed, that there was a distinct cooling of the cell during discharge, as if the energy required to separate the sulphuric acid from the solution was derived from outside as heat. If that was so, Dr. Gladstone should find by experiment an electromotive force somewhat higher than by calculation.

*Mr. J. SWINBURNE: Referring to Dr. Gladstone's theory that the variations of electromotive force were due to the liberated acid in the coatings, he would like to say as a matter of personal justice to himself that this was pointed out by him in 1883 in a little book on electrical units. Lord Kelvin's law that the electromotive force ought to be got directly from thermo-chemical data was wrong. It was pointed out by Helmholtz in 1882 that there was a second term, the temperature coefficient to be considered. In the particular case taken by Lord Kelvin (the Daniell cell) there was no temperature coefficient. It was pointed out by him theoretically that a secondary battery ought to cool on discharge. Mr. Crompton referred to the curious rise on discharge. He believed the phenomenon was due to the resistance of the cell falling, and not to the electromotive force increasing. He did not want to go into personal matters too much, but the question of self-discharge was brought before the Society by him in 1886, when he pointed out that the least impurities in the acid, anything that could settle on lead, would settle on lead, and would give rise to local action.

*Mr. W. HIBBERT pointed out that in the Paper the section which dealt with the thermo-chemical values was avowedly and professedly abbreviated; but the calculated values agreed with the observed ones very well. At the top of the curve—that was to say, when the plates were in pure H_2SO_4—the calculated value was something like 2·62 volts, whilst the observed was 2·607. At intermediate points the observed values should be, roughly speaking, something like one-tenth of a volt higher than the calculated ones. Detailed consideration of the question was reserved for future consideration. With reference to the remarks read by Mr. Robertson, a good many suggestions and fancies were mentioned in that Paper; but unfortunately experiment was directly against them. Dr. Gladstone and himself tried the effect of adding hydrogen dioxide to the cell, and found no effect worth noting—nothing that could be dwelt upon. The change of electromotive force on adding a fair amount of hydrogen dioxide was almost negligible. They also tried adding persulphate of potassium, with a like insignificant effect, so that their results could not be due to those substances. The form of the curve in Fig. 3 as one carried it down from strong to a very weak acid was not unlike the discharge curve observed in the Paper by Prof. Ayrton and his colleagues, and fully explained why there should be a critical point at about 1·8 volts. Mr. Crompton, in speaking of these experiments having been made with small cells, suggested that, therefore, they might be liable to suspicion. But the Paper was exclusively dealing with electromotive force, and in no case did electromotive force pure and simple depend on the size of the cell. Mr. Swinburne mentioned Kelvin's law as being incomplete. That was true. But Preece showed in 1883 that the temperature coefficient—which was the second term of Helmholtz—of an accumulator was exceedingly small. Such a term would, therefore, be practically negligible.

Mr. HIBBERT, in answer to a question put by the President, said that with the exception of one professed discharge curve at the end of the Paper, the experiments involved no question of current, but were pure electromotive observations made by potentiometer or condenser.

The PRESIDENT remarked that, in connection with what Mr. Crompton and Mr. Swinburne had said, it was exceedingly important to distinguish between the electromotive force of the cell and potential difference at the terminals.

*Dr. GLADSTONE, in replying to the remarks of the various speakers, said he was very glad indeed to hear that his theory had been so distinctly recognised by several experimenters before. As to the chemical changes that take place, he did not think there could be much doubt as to the formula he had put on the board in regard to the ultimate results in both directions. There might be a great deal of difference as to whether there were any intermediate reactions taking place. It was quite possible that that which Mr. Robertson put on the board in his formula might exist. These were matters of speculation, and it was one of the most difficult things in the world to tell what any intermediate stage in the chemical reaction was. They knew where they began, they knew where they ended, but of the intermediate stages they knew nothing. They could not say at present exactly whether it was the absolute sulphuric acid that was acting in these batteries, or whether it was a hydrate. The matter was not determined by means of the thermo-electric calculations. As to the presence of the liquid peroxides, and as to the difference of opinion and difference of results of experiments between Prof. Armstrong and Mr. Robertson and themselves, he was rather at a disadvantage, because Mr. Robertson knew all about the experiments of Mr. Hibbert and himself, while he did not know the experiments which Mr. Robertson had performed. At present they only knew some of the results, and they could not repeat the experiments because they did not know how to do so exactly in the form adopted. He hoped that, as in many of these kinds of investigation, it would be found that there was a certain amount of truth on both sides. He had no doubt whatever the peroxides did make some kind of change of the electromotive force; but all he could say was that they could not find any definite amount of it. As for the statements in the Paper, he thought that such coincident results from a number of different directions, together with the number of different arguments which had been brought to bear, pointed to one conclusion, that we must attach a very large amount of importance to the strength of sulphuric acid against the working surfaces of the plates when we consider the variation of the electromotive force.

LONDON CHAMBER OF COMMERCE.

ANNUAL MEETING OF THE ELECTRICAL TRADE SECTION.

The annual meeting of the Electrical Trade Section of the London Chamber of Commerce was held last Friday, at the offices of the Chamber, Botolph House, Eastcheap; Mr. R. E. B. Crompton presided.

The CHAIRMAN said that his first duty was to inform them that his period of office had come to an end; and he wished briefly to state the work which had been done during the last two years, and what still remained to be done. Speaking generally, he might, he thought, say that, on the whole, they had reason to congratulate themselves on the success of the formation of their Section. He thought it had, to a certain extent, promoted what it had been intended to promote—free intercourse between the members of their profession. They had met very frequently there, and had discussed matters in the general interest, and that had been the cause of their meeting elsewhere. Those who had previously considered themselves trade

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rivals, and hardly on speaking terms, were now upon closer terms, and had been able to work together in carrying out matters of common interest. He did not propose to take up their time by running through the list of matters, small or great, which had been undertaken in the last two years. On one occasion the Section had been in a position of antagonism towards the Board of Trade. The question arose out of the decision not to permit any longer the use of overhead wires. This decision appeared manifestly unjust after the Board had issued a very clearly laid down code of regulations on the subject of overhead wires, on the strength of which a great deal of capital had been spent. He was not one of those who upheld the use of overhead wires in crowded cities, but there was no doubt that they had their uses in country places. At any rate, he thought the decision of the Board of Trade, that, under no circumstances, would they allow the use of overhead wires, was to be combated with all their strength. As a consequence, they practically canvassed the whole profession, and, through the instrumentality of Mr. Murray and his staff, they were able to put such a powerfully signed petition before the Board of Trade that the latter practically at once reconsidered their decision. He did not think that in future the trade would be treated in such a brusque manner. One or two very important matters were started last year, but were not carried forward—principally, he thought, on account of the very happy state of their trade—that was to say, most of them had been so busily employed that they not been able to give any time to abstract questions. He might allude to the standardising of the machinery they used, so as to make it interchangeable as far as possible. The standardising of screws had now been carried out, and he thought that 98 per cent. of the manufacturers of electrical appliances were using the one form of screw which was proposed a few years ago by the Small Screws Committee of the British Association. This was now, therefore, practically universal in England: and as it was interchangeable with the Swiss screw trade, it might be said to be practically universal. By means of Mr. Murray's staff they had been able to do two other things. They were able to arrange that those who wished to visit the Frankfort Exhibition last year could do so in a body; and he thought they had derived some small advantages from this. They were received very well at Frankfort, and treated most hospitably by the Committee of the Exhibition. Another point on which they took collective action was in inducing the Directors of the Crystal Palace to postpone their Exhibition. No doubt, it would not have been half as good had it not been delayed. The display only reached its full from about the middle of February, or four months later than the date originally proposed by the Crystal Palace executive. He thought that this showed that they were right in the decision they took to endeavour to obtain a postponement. The burning matters still before them were the question of the telephone service, and how far the interests of the telephone companies and those of the heavier electrical industries could be brought together so as not to clash. In some respects it appeared as if these interests did clash; but it would be a great pity if a large amount of money were spent upon law if the questions could be settled by friendly meetings between the representatives of the different interests. A great deal had been done on the continent of Europe in this respect, and he thought he might suggest to those who followed him that if they could have before them the idea of some such Congress to settle these matters as was carried on at Frankfort last year, it might save the time, temper, and money of all concerned. He must render tribute to the extreme courtesy which had been shown to him and those who with him represented the heavier side of electrical engineering by the representatives of the telephone companies, particularly Colonel Raynsford Jackson.

Colonel Raynsford Jackson said that the next subject before the meeting was the appointment of a Chairman and two Deputy Chairmen of the section. They had observed the manner in which Mr. Crompton had presided over the Section, the skill with which he had brought the various subjects which the Section had had to deal with before it, and the devotion he had always manifested in the interests of the Section. He was sure that they would agree with him that the right thing for them to do was to ask Mr. Crompton to place his services at the disposal of the Section for another year. He therefore proposed the re-election of Mr. Crompton as Chairman of the Section.

Mr. R. J. Jenkins also testified to the admirable way in which Mr. Crompton had discharged his duties, and seconded his re-election.

Mr. Crompton said he fully appreciated their great kindness, but his decision was irrevocable.

Mr. Emile Garcke said they had already used great efforts to induce Mr. Crompton to withdraw his resignation, but they had not been able to do so. He was only echoing the sentiment of the whole Section when he said that they received Mr. Crompton's resignation with very great and sincere regret. At the same time, it must be remembered that Mr. Crompton had served for four years, and it was only right for the Chairman and the two Vice-Chairmen to tender their resignations on that occasion, so as to afford the Section the opportunity of appointing their successors. The period for which they had held office had been longer than the custom of the Chamber permitted, and the position had been a very serious addition to Mr. Crompton's numerous engagements. While he was on his feet he might be allowed to put himself in order by proposing a resolution for appointing a successor to Mr. Crompton, and he suggested to them the name of Major Flood Page, who had been Vice-Chairman of the Section since its formation, and who had devoted very considerable attention to its affairs. Major Flood Page had had opportunities of being in touch with everyone connected with the industry, and this was a great advantage in connection with the position of Chairman. He was also intimately acquainted with all the questions that came before them, and he (the speaker) felt sure that he was only serving the interests of the industry at large by proposing the appointment of Major Flood Page as Chairman of their Section. He might also refer to a suggestion which had been made to them by the Chamber namely, that the Chairman and Vice-Chairmen of the Section should be appointed for a fixed term. If they were of that opinion he would frame his motion so that Major Flood Page should be asked to accept the position of Chairman for the ensuing two years.

Colonel Raynsford Jackson seconded the motion, which was unanimously adopted.

Mr. R. S. Erskine then proposed and Mr. Henry Edmunds seconded the election of Mr. Garcke as Deputy Chairman, and the motion was unanimously agreed to.

Major Flood Page after having expressed regret at Mr. Crompton's retirement observed that it was very important for all interests to be represented; and he therefore proposed the appointment as second Deputy-Chairman of Colonel Raynsford Jackson, who represented the great telephone interest.

Mr. Jenkins seconded the motion.

Colonel Raynsford Jackson, while thanking Major Flood Page for proposing him, said he felt obliged to decline the honour.

On the motion of Mr. A. R. Bennett, Mr. Alex. Siemens was appointed a Deputy-Chairman.

At this point Mr. Crompton vacated the chair, which was then occupied by Major Flood Page.

The newly-elected Chairman, after thanking the meeting for the honour conferred upon him, said he could not for one moment pretend to occupy the same position in the electrical world as that which was held by Mr. Crompton. Mr. Crompton was thoroughly versed in the whole of the scientific and engineering aspects of the question, as well as its commercial aspect, whereas he himself represented only the commercial aspect of the industry. No one, however, could ever deprive him of the honour of having introduced the electric light into the colonies of New South Wales, Queensland, and New Zealand. He could not add Victoria, as the agent of the Company of which he was then general manager had already put up a few—he believed five—incandescent lights a day or two before he (the speaker) arrived at Melbourne. He had ever since taken an active part in the commercial side of electricity. He would endeavour to do his best to promote the interests of the Section, and he knew that he would have the advantage of Mr. Crompton's experience and that of the Section at his disposal. The next business they had to deal with was "to consider the desirability or otherwise of the Section following the precedent of other Sections of the Chamber, in convening the whole of the membership of the Section to all future meetings, appointing special committees to deal with special subjects." He thought there would be hardly two opinions on this matter. At present they had a large Section and a Committee, the latter consisting of about 35 out of 200. Any member of the Section was entitled to attend any special meetings, but could not vote. It would put a certain amount of expense on the Chamber, but if approved in future all members would be convened, and Special Committees would be appointed, and would report to the Section.

On the motion of Mr. Siemens, seconded by Mr. W. W. Beaumont, it was resolved that the Section should follow the precedent of the Chamber in regard to the matter in question.

The Chairman said that they had next to consider the attitude of the electrical trade towards the Chicago Exhibition.

Mr. Kenric Murray stated that the English Royal Commission which had been organised to promote the interests of British exhibitors at the Chicago Exhibition had requested the London Chamber of Commerce to act as the London Committee, and the Chamber had accepted this duty. Under ordinary circumstances they would probably have requested the Electrical Section to consider whether it would take any steps to be represented at Chicago, but he understood that Mr. Preece had been occupying himself specially with this question; and perhaps, therefore, it might not be desirable for them in any way to appear to be interfering with the action of that gentleman. Otherwise, if it were desired by the Section to organise an exhibit apart from individual exhibitors, this could be proposed.

Mr. Alex. Siemens suggested that this was the case where a Special Committee would be very important, and he proposed

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"That a Special Committee be appointed to report to the Section, after conferring with Mr. Preece and others, as to the attitude they recommend the Electrical Section to take with regard to the Chicago Exhibition, and that the Committee consist of Messrs. Albright, Ravenshaw, Binswanger, and Wharton."

Mr. GARCKE seconded the motion, which was carried unanimously, after the addition of the names of the Chairman and the Deputy-Chairmen to the Committee.

The CHAIRMAN stated that the next subject on the agenda paper was the telephone question. Mr. Murray informed him that nothing further had been done since the deputation of the Chamber—which had taken up the question generally—saw the Postmaster-General.

Colonel RAYNSFORD JACKSON stated that they were all aware that there was an Association for the Protection of Telephone Subscribers, and that it professed to be affiliated with the Chamber of Commerce. A circular, however, had been issued by the Association which, he thought, showed that it could not properly be affiliated with the Chamber. The Association had entered into arrangements with the New Telephone Company, had converted itself into a body of canvassers for subscribers for that Company, and had secured for the members of the Association special privileges. It had been expressly stipulated that no others should have the special privileges allowed—indeed, agreed to be given—to the members of the Association. He thought it was quite impossible for an impartial body like a Chamber of Commerce to have affiliated with it an Association which was neither more nor less than a canvassing body seeking advantage for its members at the expense of others—canvassing also to assist one Telephone Company in opposition to another, both being members of the Chamber. Having read two of the conditions—Nos. 4 and 7—which the Association said it had made with the New Telephone Company, the speaker observed that it was unnecessary for him to add anything further.

The CHAIRMAN stated that he had been informed by Mr. Murray that although the Association had in fact been affiliated to the Chamber the Council of the Chamber had complained to the Association of the use which it had made of the name of the Chamber, and the Association had promised to withdraw all such use in their future circulars.

Colonel JACKSON said he did not think that this met the necessities of the case. Here was an Association which had a specific object—to take care of the members of the Association, and, as the reward of certain privileges given to it, to canvass for subscribers for the New Telephone Company. He maintained that the work which the Association had to do did not entitle it to have the countenance, assistance, and support derived from affiliation with an impartial, independent, fair-minded Chamber of Commerce.

Mr. JENKINS said he was strongly of Colonel Jackson's opinion; and he was sure that the Council would, on consideration, see that it was detrimental to their interests for there to be any attempt to take up one scheme as against another.

The CHAIRMAN suggested that Colonel Jackson should put his remarks in the form of a resolution to be submitted to the Section with a view, if carried, to its going before the Council. It was manifest that the matter was one which must be dealt with by the Council, and not by the Section.

Mr. SYDNEY MORSE thought that the Association should have received notice of the discussion.

The CHAIRMAN stated that no Association of the kind mentioned was a member of the Section *quâ* Association; but some individual members of the Association were present as members of the Section. In giving notice of these meetings only individual members of the Section were communicated with.

Mr. A. R. BENNETT stated that he was not a member of the Association referred to, but he knew something of the matter. Colonel Jackson had said that the object of the Association was to canvass for subscribers to the New Telephone Company. That was a mistake. The object of the Association originally was to investigate complaints which had been urged by subscribers against the existing telephone service. The course which the Association had taken in supporting the New Company was the outcome of that investigation. He considered that Colonel Jackson had overstated the case in saying that the object of the Association was to canvass for subscribers for the New Telephone Company.

Mr. THOMPSON held that the present was not an opportunity for discussing the question; for, as Mr. Morse had pointed out, the agenda had not given any information which would have enabled members to obtain data on the subject. He thought it a pity that Colonel Jackson had gone out of his way to exaggerate the matter in any manner. He suggested that if it became a more burning question, and did not fall to the ground—which seemed probable—the matter should be more fully stated in a subsequent agenda paper, as that would enable members to attend the meeting, when the subject could be properly discussed from both sides. Of course there were two side to the question.

Colonel JACKSON said he regretted that he did not see Mr. Thomson, Mr. Haigh, and some other members of the Association present. He was quite certain that if they had been—for they were honourable and fair-minded men—they would see the impropriety of the affiliation of the Association with which they were connected with the Chamber, under the circumstances which he had described. As to Mr. Bennett's remarks, he (the speaker) did not choose to go into the past history of the Association. He had mentioned its present specific object as shown by its own circular. He proposed, "That considering that the Association for the Protection of Telephone Subscribers have undertaken the task, for a consideration, of canvassing for subscribers to the New Telephone Company, it should not be affiliated as an Association with the London Chamber of Commerce."

The CHAIRMAN said that the meeting would not have power to deal with such a resolution. It would be necessary for some representation to be put before the Council of the Chamber. The Section had only to do with its members, and not with the action of people who were not members of the Section.

Colonel JACKSON said he would add to his resolution "that it be submitted to the Council for the consideration of that body."

The CHAIRMAN: That is absolutely in order.

Mr. JENKINS seconded the motion.

Mr. THOMPSON proposed as an amendment, "That no action be taken by the Electrical Section in the matter of the Telephone Subscribers Association and the New Telephone Company at the present time."

Mr. ALBRIGHT seconded the amendment, which was carried by ten to seven.

The CHAIRMAN, in reply to Colonel Jackson, said that the amendment did not prevent the matter from being brought before the Council. The amendment was simply to the effect that the Electrical Section had declined, for the present, to make any representation. Continuing, he stated that the next business on the agenda was "The attitude of the Section towards the Parliamentary Committee who are to consider the whole question of electric railways in London." He thought that, as a matter of fact, all the railways had passed the Committee, and therefore he supposed there was nothing for them to do on the matter but to say "Thank you" to the Committee. The next business on the paper was "The action taken by the Chamber in reference to the question of overhead wires, and to consider the reply from the President of the Board of Trade."

Mr. MURRAY read the correspondence which had passed with the Board of Trade on the subject.

Mr. CROMPTON stated that if the reply of the Board of Trade were taken exactly as written, it would put them in rather a foolish position. It would appear as if they had gone to great pains to prepare the memorial referred to without any due cause; but it was very difficult to understand how the Board of Trade could have penned the letter of the 23rd of February, in face of the fact that it was at their own direct request—made to himself and another member of the Chamber, in the presence of a formal meeting, Mr. Courtney Boyle and his advisers, Major Cardew, and others—that they should ascertain the opinion of the trade on the subject, and if necessary, memorialise them. If that could be construed in any other way than that they should bring a memorial before them, there might be some sense in their letter. He thought, however, that they need say no more about the matter, having got what they wanted. He had only made these remarks with a view of showing that they had not proceeded without due justification.

The CHAIRMAN stated that the next matter to be dealt with was the bye-laws of the County Council in reference to overhead wires. He did not know whether any of the members present had anything to say on the question.

Mr. W. E. L. GAINE, of the National Telephone Company, thought he might explain the matter to the meeting. The bye-laws had been made by the London County Council only, but they were of no force until they were confirmed by the Board of Trade. The Board of Trade had now made an appointment to consider them and the objections of those who had any objections to make on the 28th of next month. He represented the National Telephone Company, and the question of overhead wires and the possible interference of the County Council was one not only affecting the interests of the Company and those running wires, but it was also a very large public question. He would therefore venture to suggest and, if necessary, move the appointment of a small committee of the Section for the purpose of considering the bye-laws, and also of hearing those whose interests were affected, and the public interests generally.

Mr. BENNETT seconded the motion, which was carried, the committee to consist of the Chairman and Deputy-Chairmen, Mr. Gaine, Mr. Bennett, and Mr. Henry Edmunds.

The CHAIRMAN said they had next to consider the question of electrical communication on the coasts. Since the agenda paper was prepared, the President of the Board of Trade had undertaken to make some temporary arrangement, and, therefore, he did not think that they could do anything practical in that matter that day. There was only one other question on the agenda

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paper, namely, as to the co-operation of the Section with the new Mining Section of the Chamber. He was informed that the new Mining Section was a very large and important one. What was intended was simply a kind of token of good-will—that they might be introduced to the Section in order that if and when matters arose in any way common to the two Sections—the Mining Section and their own—they should meet.

Mr. SYDNEY MORSE afterwards proposed a resolution appointing a Special Committee to consider and deal with questions affecting the interests of the Section in regard to electric traction. There had, he said, been a movement for some little time in connection with the formation of some Association for the purpose. It had been suggested that if the matter were put into the form of a committee of the Section, it would have a great deal more influence and would appeal to a wider body.

Mr. GARCKE seconded the motion, observing that he regarded it as a matter of considerable importance, not only to the Section, but also to the industry generally. The proposal had been under discussion by several members that an Association should be formed to consider the questions relating to electric traction. He thought there was quite an unnecessary tendency to form separate associations. It involved expense to all, which might be avoided, and associations never had the same standing which they had under cover of the London Chamber of Commerce. He therefore seconded Mr. Morse's resolution with considerable satisfaction. The only question of importance in connection with the formation of such a committee was its constitution, which was a very important matter, and he ventured, therefore, to suggest that it should not be hastily decided upon. It was very desirable that the gentlemen who contemplated the formation of such an Association should be consulted, and, if they would do so, that they should serve on the proposed committee. For that reason he would suggest that it was very difficult for them at that meeting to determine who were the best and most qualified men to serve on such a committee, and that the matter be left to the consideration of the executive Committee, consisting of the Chairman and Vice-Chairmen, to report upon again.

The CHAIRMAN desired to say a word endorsing what Mr. Garcke had said. When they began the Section they all hoped that there would be no separate associations as regards their trade, and that they would be able to do all their business in connection with the Section. It was a matter of great regret to them that the supply companies had thought it necessary to form an Association. He believed that the Section would be of infinitely greater use if, whenever it was thought advisable for an Association to be formed, those who contemplated such a proceeding would communicate with the Section first to ascertain whether the Section could not do the work.

Mr. GAINE said that the unfortunate telephone company had come up again in regard to the resolution before the meeting. He would like to know what it meant. It was known to a great many members of the Chamber that a very difficult question arose when certain classes of electric traction were used upon tramways as between the electric companies and the telephone companies. That question had been, as, perhaps, many of them knew, threshed out before the Parliamentary Committee, with the result that certain protective clauses had been inserted in the interests of the telephone companies in the various Electric Bills before Parliament. What he wanted to know was whether the idea and intention of appointing the committee now proposed was to re-open a question which, he ventured to think, had been decided by Parliament.

Mr. THOMPSON, in support of Mr. Gaine, said he did not think it was desirable for the Section to commit itself to any decided line of action by any "snap resolution," such as that proposed. While he thought it desirable that the Chamber should take some action, yet, in proportion as the strength of the voice of the Chamber was as had been described, so it was important that they should not take any action without very careful consideration, and without the Section having an opportunity of carefully considering the subject. The matter was not upon the agenda paper, and therefore they could not have come to the meeting prepared with any data to enable them to discuss it. He therefore proposed as an amendment that the matter be left over to another meeting and be put upon the agenda paper. In the meantime they would have an opportunity of deciding who was best able sufficiently to represent the Section, and he thought they would serve their own interests in that way very much better than by taking a vote on the subject that day.

Mr. CROMPTON said he had heard that an Association was being formed which he thought it best to say at once would be antagonistic, to a certain extent, to the telephone interest; and it occurred to him that it would be very much better, and would be carrying out the objects of the Association, if the whole question were looked into from both sides by a full committee of the Section, consisting of members of both interests. He thought they should really see if a *modus vivendi* could not be arrived at by a number of business men sitting round a table, instead of confiding their interests to lawyers and electrical experts. He thought that any great delay in bringing together what he believed would be a friendly committee might be the cause of a great expenditure of money, great loss of time, and irritation between the branches of their industry, which might be avoided. He thought the telephone interest should be fully represented on the committee, and by their best men, in the same way that the traction interest should be represented by their best men; and he could not help thinking that they could, under such circumstances, arrange to try out this question—the use of the earth—under one chosen arbitrator, and so save the enormous expense which they saw looming in the distance. The question was going to be tried out in America, on the Continent, and here; and he thought they would do well in trying it out among the Section. For that reason he had been delighted to hear Mr. Morse bring the matter forward. He saw disadvantage in delaying the appointment of a Committee.

Mr. GAINE said he would have liked to fall in with Mr. Crompton's suggestion, because he believed that wherever possible conferences should be held. His position in the matter was this—that the question between the telephone companies and the electric traction companies had been thoroughly threshed out in Parliament. For the last two or three Sessions every Electrical Traction Bill had had a protective clause put in it by Parliament for the benefit of the telephone companies. He did not oppose the committee, but he could not go to that committee with any suggestion that the question, so far as they were concerned, was an open question—that was to say, he could not give up what, at very great expense, had been fully threshed out in Parliament. He thought there were only one or two cases in the country of statutory powers, obtained in earlier days, where such protective clauses for the telephone interests did not exist; and in one of those cases—Leeds—legal proceedings were pending as to whether without that protection the Telephone Company was not entitled to protection under the law of the land. The English of it was, which of the two companies was to double their wires. Let the committee be appointed; but, as far as the National Telephone Company was concerned, they could not go to that committee with any suggestion that they departed from the position they had taken up before the Courts and before Parliament.

Mr. BEAUMONT observed that the remarks of Mr. Crompton and Mr. Gaine seemed to lend importance to the resolution. No doubt, it was a subject of great importance, and he therefore thought that they ought not to be in too great a hurry to impose on the Chairman and the Vice-Chairmen still greater responsibility than they had done by asking them to decide right off what should be the formation of the committee to consider the question. He would second Mr. Thompson's amendment.

Mr. MORSE said it seemed to him that many members had entirely overlooked one most important point, namely, the powers of the proposed committee. Mr. Gaine spoke as if by joining the committee he would necessarily have to give up something which he might have; but the committee was simply asked to consider and report. If the trade as a whole could meet the telephone companies as a whole, and could discuss the matter, did any one mean to say that there was not a fair medium course that might be arranged? That was the object of the Association, and that was the object of the committee which the meeting was asked to appoint.

Colonel JACKSON said he had listened with considerable interest to Mr. Crompton's remarks on the proposal, and he concurred with that gentleman that it was desirable that the representatives of the two interests mentioned should meet in conference to see whether the differences between them could not be settled; but, of course, as Mr. Gaine had said, the telephone company could not undertake to give up its legal rights as a preliminary, or to lay its great industry prostrate before any other industry. Short of that, however, it was advisable that the representatives of the two interests should meet in friendly conference.

The CHAIRMAN observed that Mr. Thompson had rather suggested that the matter under discussion was not on the agenda, but they said "other business" in the paper. He must say respecting what had fallen from Colonel Jackson that no one would dream that any one going into the committee would give up any rights. It was, as Mr. Crompton had said, a matter of great importance that they should see whether a *modus vivendi* could not be arrived at among themselves, instead of having to put money into the pockets of lawyers and experts.

Mr. THOMPSON said he would propose a compromise. He was at one with Mr. Morse as to the first point in his resolution, but he would suggest that the *ex officio* members of the committee should in the meantime act.

After some further discussion the following resolution was agreed to:—"That a Special Committee be appointed to consider and deal with the questions affecting the interests of this Section in regard to electric traction, and to report from time to time to his Section."

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Mr. THOMPSON then proposed "That the Chairman and Vice-Chairmen of the Section be the Committee, with power to add to their number such names as they may nominate, and submit to the next meeting for confirmation."

Mr. BEAUMONT seconded the motion.

Mr. CROMPTON said he would propose an amendment. The Committee could not get to work until it was formed with a full complement of members. It was a waste of time of a month to postpone, as had been suggested, the full nomination of the Committee; and he proposed "That the Committee be forthwith nominated by the Chairman and Vice-Chairmen."

The amendment was seconded, and put by the CHAIRMAN, who declared it carried.

The proceedings then terminated

THE GOVERNMENT AND THE TELEPHONES.

The following is a *précis* of the Bill introduced last week by the Postmaster General, entitled "A Bill to make further provision respecting Telegraphs."

Clause 1 states that, as it is expedient to raise money with a view to carry into effect the scheme of the Postmaster-General for the development of that part of the telegraphic system of the United Kingdom which is called the telephonic system, and, in particular, with a view to purchase and provide the main lines of telephonic communication, the Treasury shall, with this view, issue out of the Consolidated Fund such sums not exceeding in the whole the sum of £1,000,000, as may be required by the Postmaster-General.

Clause 2 stipulates that if the Postmaster-General considers that the inhabitants of any district, or any public authority, are debarred from the public convenience of telegraphic communication owing to the refusal of any person to consent to the construction or maintenance of a work by the Postmaster-General, the Railway and Canal Commission may be invoked; and that Commission, if satisfied, after holding a local inquiry, and giving an opportunity for all persons interested to be heard, that the inhabitants are so debarred, may make an Order consenting to the construction of the work, either unconditionally or subject to such pecuniary or other conditions as the Commission think just; and such consent shall, for all purposes, be of the same effect as if given by the said person. The Postmaster-General may introduce into Parliament a Bill confirming any such Order; and the Order, when so confirmed, with any modification made therein by Parliament, shall have full effect.

Clause 3 extends the provisions of the Telegraph Acts, 1863 and 1878, relating to streets, &c, within the limits of any town having a population of 30,000 inhabitants or upwards, to streets, &c., within the limits of any urban sanitary district.

Clause 4 relates to telegraph lines constructed irregularly or by persons other than the Postmaster-General, and extends the protective clauses of the Telegraph Acts of 1863 and 1878 to such lines. Sub-section 2 runs as follows:—

> Where, either before or after the passing of this Act, any consent for the construction of a telegraphic line along a street or public road has been given, subject to any term, condition, or stipulation, to a person through whom the Postmaster-General claims, the Postmaster-General may give a notice to the authority or person giving the consent asking for the withdrawal of that term, condition, or stipulation; and if the authority or person fail to withdraw it within twenty-one days after the notice is given, a difference shall be deemed to have arisen between that authority or person and the Postmaster-General, and shall be determined in manner provided by sections four and five of the Telegraph Act, 1878.

Clause 5 relates to licensees of the Postmaster-General, licensed to transmit any telegrams within the meaning of the Telegraph Acts, 1863 to 1889, and authorises the licensee during the time and within the area specified in the licence, to exercise the powers, so far as applicable to telegraphic lines above ground, which are conferred on the Postmaster-General by the Telegraph Acts, 1863 and 1878, and by the provisions of this Act relating to Provisional Orders, or such of those powers as are specified in the licence. A licensee is not, however, to exercise any of these powers without the consent, in London of the County Council, and in any urban sanitary district outside London of the Urban Sanitary Authority, and elsewhere of the County Council, and he will have to comply with any regulations of these authorities.

Clause 6 runs as follows:—

> (1) Any Company or person authorised to lay an electric line within the meaning of the Electric Lighting Act, 1882, may, with the approval of the Board of Trade, and by agreement with the Postmaster-General, or, if so authorised by the Postmaster-General, with his licensee, place, or authorise the Postmaster-General or his licensee to place, telegraphs in the trenches, tubes, pipes, or apparatus used for the purpose of such electric line.
>
> (2) The enactments relating to the Company or person in relation to the powers, operations, trenches. tubes, pipes, and apparatus of sueh Company or person for the purpose of the electric line shall, so far as applicable, extend to the said telegraphs, and to anything done in pursuance of this section.

Clauses 7 and 8 are respectively saving and extension of meaning clauses. Clause 9 contains various definitions. Clauses 10, 11, 12, relate to the application of the Act to Scotland, Ireland, and the Isle of Man. Clause 13 relates to the title of the Act.

TREASURY MINUTE.

The following Treasury Minute (dated May 23rd), upon the Proposals for the Development of the Telephone System in the United Kingdom, has been laid before Parliament:—

My Lords have before them the proposals of the Postmaster-General for carrying out the policy which has been adopted by Her Majesty's Government for development of the telephone system in the United Kingdom.

1. It is the object of these proposals, while preserving the property in the telegraphs, which has been paid for by the nation, to secure that expansion of the telephone system which is called for by public opinion and the necessities of commerce. It is impossible to continue the present system under which the telegraph revenue is seriously suffering, while, on the other hand, the extension of telephones is checked in a manner which cannot be permanently maintained.

The proposals of the Postmaster-General will enable the telephone companies and the Post Office to co-operate in services to the public.

2. The telephone companies are at present restricted to oral communications. The scheme prepared by the Postmaster-General will in one direction, as hereafter explained, remove that restriction, and it proposes the establishment of trunk wires throughout the United Kingdom.

3. Unless trunk wires are in the hands of the State, a monopoly, injurious to the public interest, would inevitably ensue, to the advantage of the Company which first laid down such trunk wires.

4. If, on the removal of the restriction to oral communications, the companies were allowed themselves to write down and deliver messages and a network of trunk wires were spread over the country by private enterprise, the distinction established by Mr. Fawcett between the business of the companies and of the Post Office would disappear, and rival systems of telegraphy would be working side by side where Parliament intended that there should be only one.

5. For this reason it is proposed that the Post Office shall write down and deliver the messages, and that the Post Office shall provide a national system of trunk lines. United action on the part of the companies and the Post Office is necessary to the success of the scheme.

6. It is proposed that the companies should abandon their right to construct trunk wires, and that the Post Office should purchase from them such as they have already erected; and that in addition to this the Post Office should gradually provide additional trunk wires, so that there may ultimately be a complete system of communication between all the important towns in the kingdom. It is further proposed that a connecting link between Great Britain and Ireland should be furnished by a submarine cable, and that the whole system should be open, not only to the subscribers of the companies, but also to any member of the public who may choose to come to a post-office for the purpose of using it.

7. The companies will connect their exchanges with the offices of the Post Office, in order that their subscribers may telephone messages—

(*a*) For transmission over the public telegraphs;
(*b*) For transmission through the post as letters;
(*c*) For delivery as express letters;
(*d*) That they may be for the service of express messengers; and may
(*e*) Request to be placed in telephonic communication with other towns by means of the trunk wires of the State.

8. The Post Office will make no charge for the service of its officers who attend to the wires connecting the exchanges with the local post offices, and will pay the companies a commission of 5 per cent. on ordinary telegrams telephoned to those offices for transmission by the public telegraphs.

9. The Post Office will withdraw its veto on the establishment by the companies of public call offices in the houses and shops of sub-postmasters. It will further be a consideration whether, if the convenience of the department will permit it, head, district, and branch post offices should be allowed to be used as call offices, &c., subject to such payment by way of rent as may be agreed on.

10. As far as practicable the Post Office will provide underground wires at an agreed rent to connect together the exchanges of a company within one and the same exchange area, so that municipal authorities may not have to complain of their streets being disturbed by the companies, which, in some places, might be in competition.

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11. The Post Office, where it can permit telephone companies to use railways, canals, or other property, over which it has acquired exclusive rights of way for telegraphs, will charge a nominal sum of 1s. per mile of wire, instead of 20s. as at present.

12. Parliament, by a Bill now about to be introduced, will be asked to confer on the companies, subject to the consent of the local authority, powers for the erection of the wires required to connect their exchanges with the houses of their subscribers.

13. The messages telephoned to post-offices for delivery will have to be limited in length, and it is proposed to adopt the two-fold limit of three minutes and 30 words. The charge will be the same as for an ordinary express letter, viz., 3d., if the address be within a mile of the post-office where the message is written down.*

14. For conversations on the trunk wires of the State the following charges will, it is thought, be equitable, while, at the same time, sufficient to secure a margin of profit.*

For any distance not exceeding 20 miles	3d.
For any distance exceeding 20 miles and not exceeding 40 miles	6d.
For every additional 40 miles or fraction thereof	6d.

15. A charge of 6d. for 40 miles has been sanctioned by the Treasury for the trunk wires already provided by the Post Office; but the charge of 3d. for 20 miles is new. The Post Office consider it necessary that there should be this lower charge for the short wires.

Longer distances cannot be charged for at a less rate, as, although it is true that the terminal expenses are a fixed quantity, the expenses of construction and maintenance will, even in proportion, increase greatly with the length of the line. Where a submarine cable is used, or where exceptional expense is incurred, an additional charge will be made.

16. As in the case of the London-Paris telephone line, the period of each conversation will be three minutes, and two consecutive periods will be allowed for a double payment.

17. My Lords will examine with care such schemes as may be successively submitted by the Post Office for the gradual construction of new trunk lines.

In the course of a few months wires can be erected on existing poles from London to certain principal places, and progress can be made, as convenience permits, with further wires in many directions.

These works would be carried out in such a manner as to supplement and extend the system acquired from the companies.

18. It must be clearly understood that the right of the Post Office to establish telephone exchanges, which was reserved by Mr. Fawcett, will be maintained, the department holding itself ready, as in the past, to comply with the reasonable demand of any town or district for telephonic facilities.

19. As to fresh licences, no further licence for the whole country will be granted; and even for a licence to establish an exchange in a particular town no application will be entertained unless a formal resolution in its favour has been passed by the Corporation or other municipal authority, and evidence given that there is sufficient capital subscribed to carry out the undertaking. In this way competition will not be excluded, but a check will be imposed on the formation of companies whose sole object it is to force the existing licensees to buy them up.

But although this is the policy which commends itself to Her Majesty's Government, it must be distinctly understood that, should licences hereafter be granted on other principles, no Company now or hereafter to be licensed will have any ground to complain of breach of contract or want of good faith on the part of the Postmaster-General.

It will be a condition of any licence to a new Company that their system must be constructed entirely of twin wires or metallic circuits, so that there may be an assurance of its efficiency.

20. The royalties now payable by the companies to the State will remain unchanged. The other conditions imposed by their licences will remain unchanged, except so far as they may be modified by the policy indicated in this minute.

21. In conclusion, it may be stated that the intention is to meet, as far as possible, the views of municipal authorities, to aid the telephone companies in the improvement of their exchange system, to place additional facilities at the disposal of the public, and to establish trunk wires between the more important towns throughout the country.

My Lords concur.

* These charges are independent of the charges which the companies made on their own account for sending a telephone message.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—MONDAY, MAY 30TH.

The Great Northern and City Railway Bill.

Mr. PICKERSGILL moved that it be an instruction to the Committee on the Great Northern and City Railway Bill that they do insert a clause reserving to the London County Council a power to purchase the undertaking after the expiration of a limited period on terms similar to those provided in Section 43 of the Tramways Act, 1870. He urged that no difference should be made in this matter between tramway and railway companies, and he invited the House to declare the principle that the public should have the opportunity of purchasing this and other local railways after the expiration of a certain time.

Mr. WHITMORE hoped the House would not agree to the instruction. The Joint Committee which considered the group of Bills seeking to provide underground communication in the metropolis were satisfied that the acceptance of such a proposal would endanger the success of the scheme, because it would prevent the capital being subscribed. The Great Northern and City Railway, moreover, would not be merely a local line, but would supply a new terminus for the Great Northern system, and, consequently, it did not come in quite the same category as the other schemes.

Sir J. PEASE thought that this notion must have taken the House a good deal by surprise. The principle involved was a very large one—that all new railways constructed in the district of the London County Council should become, like tramways, the property of the County Council at the end of a certain period—and he hoped the House would hesitate before it sanctioned such a principle.

Mr. R. G. WEBSTER observed that the London County Council was such a grasping body that one was always in a state of wonder as to what it would ask for next. If the demands of the County Council were acceded to in these railway matters there would be an end of schemes which would provide a great deal of remunerative employment to the working classes. The London County Council was a municipal cuckoo. It introduced no great schemes of its own and tried to interfere with those of other people. The proposal before the House was quite unworkable, and he trusted it would be rejected.

Mr. HOWELL supported the motion, believing that it would result in advantage to the metropolis. He looked forward to the time when the management of the railways would be taken over by the State.

Mr. KIMBER thought that this proposal was made by the County Council in the hope of being able ultimately to direct and control all the labour of London. It wished to command the army of labour in order to acquire the suffrages of the masses for a particular party. If the proposal before the House were agreed to they would certainly receive similar applications from large and small provincial towns and would not be in a position to refuse them.

Mr. COURTNEY opposed the motion on the ground that the proposal was disapproved by the Joint Committee of Lords and Commons who had considered the subject.

Mr. J. S. GATHORNE-HARDY explained the reasons which had led the Committee to the conclusion that the plan was inexpedient.

Mr. PICKERSGILL explained that, although he was authorised by the County Council to move this resolution, yet, in deference to the views of the hon. member for Chelsea, he did not intend to press it, but would take a division upon the next resolution.

The resolution having been by leave withdrawn,

Mr. PICKERSGILL moved a similar resolution with reference to the Central London Railway Bill,

The House divided, and the numbers were—

For the resolution	83
Against	127
Majority against	—44

The resolution was therefore rejected.

TUESDAY, MAY 31ST.

Select Committee on the Electric Railway Schemes.

The Select Committee of the House of Commons, which has been appointed, with Sir John Kennaway as chairman, to consider the various schemes for providing underground electrical railway communication in different parts of the Metropolis, held their first meeting on Tuesday, May 31st. The first scheme dealt with by the Committee was that of the proposed Baker-street and Waterloo Railway.

The promoters of the Bill were represented by Mr. Pember, Q.C., Mr. Cripps, Q.C., and Mr. Francis; and the numerous opponents were represented as follows:—The Metropolitan Railway Company by Mr. Littler, Q.C., and Mr. Worsley Taylor, Q.C.; the South-Eastern Railway Company also by Mr. Littler and Mr. Worsley Taylor, in addition to Mr. Tufton; the London County Council by Mr. Freeman; the Trustees of the Constitutional Club by Mr. A. G. Rickards; the National Liberal Club Buildings Company by Mr. Erskine Pollock, Q.C.; the Conservators of the River Thames by Mr. Littler, Q.C., and Mr. Claude Baggallay; the Vestry of St. Martin's-in-the-Fields by Mr. Meysey Thompson, Q.C.; and the Gordon Hotels Company (Limited) by Mr. Pope, Q.C., and Mr. Freeman. Other opponents to the Bill, who did not appear by counsel, were the vestries of Marylebone and Lambeth, the Metropolitan District Railway Company, the Union Bank of London, the Sun Insurance Company, the Hotel Victoria, and the County Fire Office.

Mr. PEMBER, in opening the case for the promoters, explained that the Bill proposed to constitute an independent Company with a capital of £1,250,000, to make a line two miles seven furlongs in length, of which it was estimated the cost would be £990,000. In addition to the stations at the termini it was proposed to place stations at Charing Cross, Piccadilly Circus, and Oxford Circus. He pointed out that practically the lines proposed had received to some extent the sanction of Parliament through the report of the Joint Committee; and he therefore asked whether it was necessary to overlay the case with fresh evidence, or whether the natural and wisest course would not be to assume that there had been a *primâ facie* case made out for the line, and to call only formal evidence, and then to deal with the objections which were raised by the opponents as reasons why the line should not be made.

The CHAIRMAN said that before deciding that point the Committee would like to know what the petitions were, and the nature of the objections raised.

Mr. PEMBER thereupon dealt at length with the various petitions against the Bill; and at the conclusion of his speech,

The CHAIRMAN said that the Committee concurred in the report of the Joint Committee, that it was desirable that some means should be taken to relieve the congested and over-crowded streets of the Metropolis, and to open a communication between the north and south of London. On those points they would not require evidence.

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Mr. PEMBER said that some of the petitions raised a question as to the value of electricity as a motive power. He did not know how far the Committee would desire evidence on that point.

The CHAIRMAN said he thought it would be desirable to have some evidence on that point. It would be very easy to put the existing Electrical Railway in the box, as it were.

Mr. PEMBER said that Mr. Greathead would be able to give any evidence on that point.

Mr. J. H. GREATHEAD was then examined by Mr. Francis, and said that, in addition to being engineer for the Liverpool Overhead Railway and the City and South London Line, he was engineer, in conjunction with Mr. Galbraith, for the present scheme. The only practical communication along the route was by omnibus, which was inconvenient and very slow, and the proposed railway would be three times as expeditious as the omnibus. The sharpest curve on the line would have a radius of four chains, there being several of that kind which compared favourably with the curves on the City and South London, which were worked with perfect safety. The steepest gradient would be one in 55, as compared with that on the South London of one in 30. The depth below the surface would vary from 85ft. at Oxford-street, to 15ft. at Waterloo, and the Thames would be passed under at a depth of 16ft. 6in. below the bed of the river. The deviation clause would allow them to go as much deeper as they liked, but there were limits above which they could not raise it. On the north side of the Thames the line would be for the most part in London clay, and on the south side it would pass into the overlying strata of gravel and sand, but there would be no difficulty whatever in tunnelling in either strata without any disturbance of property overhead. He described the mode of tunnelling by means of a shield, and said that to avoid any possible danger it had been decided by Sir John Fowler, Sir Benjamin Baker, and himself, in the Central London line, to also construct the station tunnels by means of shields, and the same course would be followed with this line. Referring to the City and South London line, he said that for 18 months they had run nearly 350 trains a day, and though there had been some slight hitches and delays, the traffic had been on the whole conducted in such a way as to compare favourably with the general suburban traffic on most of the railways, especially during the early part of the year, when on other railways the fog was so dense that it completely upset the working of other lines. There could be no question as to the advantage of electricity as a motive power. In addition to the £930,000 for the cost of the line, including contingencies, £300,000 would be required for rolling stock, hydraulic lifts, electric plant, and so on. He explained the mode of ventilation, and said that it was anticipated the line would carry 14,000,000 passengers a year.

Mr. LITTLER cross-examined the witness as to the possible interference with the Metropolitan St. John's Wood Railway line in case they should require either to widen or to carry another line beneath their own; but Mr. Greathead denied that the electric line would interfere with any such projects if contemplated, and said he was not aware that the South-Eastern Company had, for many years past, been considering the best method of themselves getting across London so as to get a junction of the Northern with the Southern lines. On the City and South London line more trains could be run if they had more rolling stock than at present.

Mr. LITTLER called attention to the fact that this Company had a large amount of unissued capital, and asked how it was they did not provide themselves with more rolling stock.

The CHAIRMAN said the Committee were not inquiring into the financial policy of the City and South London Company.

Mr. LITTLER: But if the line is running trains every 4½ minutes instead of every 2½ minutes, and I show that it is only earning £9,454 a year, whereas to make it pay decently it ought to earn £40,700, that surely is a matter to be considered. This is a line of about the same length, to be worked in the same way and for precisely similar purposes. This question was not gone into before the Joint Committee because the Joint Committee did not think it worth their while to be assisted by those who knew most about the matter, namely, the solicitors and managers of the railways.

At this point, by special request, Mr. Charles Scotter, general manager of the London and South-Western Company, was interposed as a witness, and gave general evidence in favour of the line and its prospects of traffic In reply to Mr. Pope he said the South-Western Company were not giving any financial assistance to the promoters.

Mr. GREATHEAD was then further cross-examined by Mr. Pope as to the treacherous character of the ground beneath Northumberland-avenue, but he would not admit that there was anything "ticklish" or "risky" about the operation of tunnelling there. Working with compressed air was very much more difficult and expensive.

Mr. POPE: Not so much as letting down the Hôtel Métropole. Where is your capital to come from if you do let it down?

Mr. FREEMAN said the County Council were also dissatisfied with the provisions as to the manner in which the work was to be carried out under Northumberland-avenue.

The CHAIRMAN: Are you prepared to submit any provisions which would satisfy them?

Mr. FREEMAN said that he would consult his clients on the matter.

The Committee adjourned till Wednesday.

WEDNESDAY, JUNE 1ST.

At the sitting of the Committee on Wednesday Mr. PEMBER announced that to meet the objections of the trustees of the Constitutional and National Liberal Clubs, the Gordon Hotels (Limited), Hotel Victoria, and other petitioners in Northumberland-avenue, having regard to the exceptional character of the buildings, the promoters had drawn up a clause which provided that "the railway and station tunnels other than the shafts and approaches to stations shall be constructed between the statue of King Charles I. at Charing Cross and the north side of the river Thames at such a depth that the exterior surface of the crown of the tunnel shall be not less than 10ft. below the surface of the London clay; but this provision shall not apply to the case of short pockets or pot holes in the clay if such are met with in the line of the railway extending below the general surface of the clay;" and that "prior to commencing any part of the works situated between the points aforesaid the Company shall make trial borings throughout the entire line of the proposed tunnels between the points aforesaid for the purpose of ascertaining the nature of the soil through which the tunnels are to be constructed, and, if the engineer to be appointed by the petitioners shall so require the whole or any part of the railway between the points aforesaid shall be constructed under compressed air." The engineer to the petitioners is to have liberty of inspecting the works, "and if such engineer shall be of opinion that the construction of the works or other operations of the Company are attended with danger to the property of the Northumberland-avenue petitioners, the Company shall forthwith adopt such additional measures and precautions, including additional borings, as may be considered necessary for the purpose of preventing damage or injury." Compensation is to be paid for any structural damage, and no generating station is to be constructed within 100 yards of any of the properties in Northumberland-avenue.

Mr. POPE, for the petitioners, intimated that the clause would afford a satisfactory basis of agreement; and later in the day it was announced that an arrangement had been come to.

Mr. J. H. GREATHEAD was recalled, and in reply to further questions in cross-examination stated that it was proposed to place the electrical generating plant on the south side of Waterloo Station. There would be no interference with the Metropolitan sewers, or with the Thames Embankment wall. The average speed at which the trains would run would be 18 miles an hour. In re-examination by Mr. Pember, he said they proposed, on the Baker-street-Waterloo line, to spend three times as much on equipment as was spent on the City and South London Line. The Baker street tunnels would be larger, and the stations longer; and, if all the capital powers were exercised, the cost would be £550,000 a mile, as against £250,000 to £300,000 a mile on the City and South London. He considered that his estimate of 14,000,000 passengers over the three miles of line per annum to be reasonable; and, at an average fare of 2d. a passenger, it would pay a dividend of 4 per cent. When the Metropolitan Railway was a short line of 4½ miles it carried 5½ million passengers per mile.

Mr. W. R. GALBRAITH, joint engineer to the line, gave further details as to the method of construction, the necessity for the line, the amount of traffic that it would command, and the absence of interference with properties. The promoters, he said, would be prepared to make an access between the Metropolitan Station at Baker-street and the station of the proposed line, which would be a convenience to the public and an advantage to the Metropolitan Company. They would also desire to have a station on the south side of Regent's Park, near Portland-road Station, but they were under an obligation to the Crown not to break the surface of the Park. At Charing Cross, opposite the Nelson Monument, land had been scheduled for a station; but they did not intend to make one there unless they were driven from the other end of Northumberland-avenue.

This concluded the case for the promoters.

Mr. LITTLER addressed the Committee on behalf of the Metropolitan and South Eastern Railway Companies, stating that the report of the Joint Committee would have more force if they had allowed the parties to be represented before them. The line, he said, would be absolutely and totally useless for ordinary railway traffic; was a useless and stupid line, and would carry next to no traffic. He referred to the experience of the City and South London line, which carried only 14 passengers per train mile, or 42 passengers per trip on the average, and asked if that was a result likely to encourage anyone to invest money in this line, even if it were authorised. The net earnings on the South London last half-year were only £4,727, out of which £4,304 was absorbed by interest on the debentures, and £150 on preference shares, which left a magnificent total towards paying dividend on capital of £301. That was the financial result to those who had been foolish enough to be entrapped by prospectuses into putting their money into the line. The learned counsel had not concluded when the Committee again adjourned.

LEGAL INTELLIGENCE.

The Lane-Fox Patent: Petition for Prolongation.

The Earl of Selborne, Lord Watson, Lord Hannen, and Lord Shand, sitting as members of the Judicial Committee of the Privy Council, on Saturday had before them the case of Mr. Lane-Fox's Patent in the form of an application to fix a date for hearing the arguments and evidence in favour of the prolongation of the patent. When the case was called on by the Registrar, the Earl of Selborne said their Lordships would sit to hear this case on Thursday, July 7th.

Western Counties and South Wales Telephone Company (Limited) v. Bournemouth and District Electric Supply Company (Limited).

In the Chancery Division, on Friday last, the case of the Western Counties and South Wales Telephone Company v. Bournemouth and District Electric Supply Company again came before Mr. Justice Chitty in the form of a motion asking that a writ of sequestration might issue for an alleged contempt of Court by the Bournemouth and District Electric Supply

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Company in wilfully disobeying an order of the Court, made on the 8th of April last, directing that the defendants should be perpetually restrained from working or using their electric lighting system, apparatus, and works in the town and neighbourhood of Bournemouth, in such a manner as to injure or interfere with the plaintiff's exchange system, and in particular from causing or permitting injury to the plaintiffs' system, either by induction or leakage, or from any other cause connected with the defendants' conductors.

Mr. FARWELL, Q.C., who supported the motion on behalf of the plaintiffs, said after the order of the 8th of April had been made the defendants applied to his clients to suspend its operation in order that they might have time to complete their work, and the plaintiffs acceded to their request, giving them until April 22nd. Subsequently the plaintiffs further extended the time to enable the defendants to remedy the defects in their system till May 6th. On May 5th a disturbance commenced which had continued. It commenced when the defendants' electric current was turned on, and it ceased when the current was turned off. The defendants had admitted that the fault was theirs. They said that their lines were in the first place improperly laid down, and in consequence of their not being allowed sufficient time to do the work properly; but that now their system had been improved. He (the learned counsel) believed that there had been some improvement, though there was still a disturbance, and the plaintiffs' subscribers continued to complain. Some were threatening to withdraw their subscriptions because, they said, it was useless for them to go on unless the disturbance was effectually stopped. The defendants had placed their wires underground, but that had not cured the disturbance of which the plaintiffs complained. He had several affidavits in support of the plaintiffs' case, that their telephone system was seriously interfered with by the electrical disturbance due to the defendants' electric lighting apparatus. On Thursday, May 5th, after the defendants' electric current had been turned on, the disturbance was so serious that it rendered the plaintiffs' telephones useless. Unless this serious disturbance was put an end to forthwith, it would be useless for the plaintiffs to attempt to carry on their business at Bournemouth, Poole, or Christchurch. He believed that if the defendants had constructed their underground lines with proper care the disturbance would have been avoided, as in every other place where the two systems worked together. Mr. Alfred Haynes, a chemist of Bournemouth, in his affidavit, stated that the disturbance on the line connected with his premises had been intolerable. In the day time there was no interruption whatever, but immediately the defendants' electric current was turned on there was great buzzing in the telephone, which had rendered it impossible for him to use the instrument.

His LORDSHIP: How does the disturbance arise?

Mr. FARWELL: From induction or leakage.

Mr. BYRNE, Q.C., who represented the defendant company, said his clients had complied with the regulations of the Board of Trade in every respect.

Mr. FARWELL, continuing, said: The issue his lordship had to try was whether the defendants were responsible for the disturbance which undoubtedly existed.

His LORDSHIP inquired whether it was suggested that the plaintiffs should do anything.

Mr. FARWELL replied in the negative. Prof. Silvanus Thompson, however, said that a return wire was desirable in the plaintiffs' telephone system. The defendants had filed several affidavits in support of their case. Mr. W. M. Mordey stated that on the 25th of May he took the opportunity of listening at the telephone at his hotel and at the defendants' works while there was a good deal of summer lightning about, and found that each flash was accompanied on the telephone by a rapid crackling noise, which was very disturbing, rendered talking difficult, and afforded a striking instance of the way in which a telephone system with earth returns was affected by all kinds of electrical effects. The defendants electric light machinery was at work and caused a faint hum, but it did not interfere in any way with conversation. Prof. Silvanus P. Thompson stated that he visited Bournemouth on May 23rd, and listened through the plaintiffs' instruments during the evening when the defendants' electric light system was in operation, but could not detect any disturbance worth naming or that interfered in any material degree with the operations of the plaintiffs' system. He spoke through the telephone from the Hotel Mont Doré and also through the telephone from the exchange to the defendants' works in the Bourne Valley. There was a faint hum like that to be heard in a sea shell when held close to the ear, which was doubtless caused by the defendants' lines; but the talking to both places was carried on without the slightest difficulty. There were occasionally stray noises, but those were not due to the electric light circuits. There was the well-known crackling sound due to the plaintiffs' carbon transmitters, and there were occasionally whizzing sounds due to the use of electric bells on other lines in the plaintiffs' system. He spoke through several times, and talking went on unimpeded. He knew of no reason why the humming sound should have been worse than it was on the occasion of his visit, unless there had been a leakage of electric current from defective joints, now removed from the circuits. He thought such leakages were excusable where the work had been done at high pressure. The noise was far worse on the London telephone exchange, where the hum was more distracting than at Bournemouth, and yet business was done. It was well known that such humming and stray sounds would be avoided by the use of proper metallic return wires, as was done in all modern exchanges. He referred to the telephone exchanges at Newcastle and Manchester as examples of modern exchanges in which there was no possibility of humming, cross-talk, or any interference from stray currents. Stray currents, whether arising from telegraphs or electric lighting, or from the natural earth currents which flowed in the coil, were certain to be picked up by the old-fashioned system that employed the soil of the earth instead of proper return wires. Where such metallic returns were not employed, disturbance was, in his opinion, inevitable. The defendants were doing all they possibly could not to interfere with the plaintiffs' exchange. Speaking generally, he could state confidently that conversation could be carried on at Bournemouth on the plaintiffs' lines with far greater comfort and ease than was the case in most districts in London. Mr. J. C. Bailey, electrical engineer at Bournemouth, in his affidavit, stated that he inspected both the plaintiffs' and the defendants' lines on the 4th inst., and that he found the plaintiffs' lower wires had been carelessly fixed. They were slack and appeared to be temporary wires. There was a good deal of wind, and plaintiffs' wires were blowing against their own stays, and also against the stays of the defendants, and in some cases the wires were resting on the roofs. All these things would cause disturbance in the telephone. The defendants' wires in the same place were in good order, high up above the telephone wires, and properly strained, so that there could be no contact. Mr. Alfred Jolliffe, house and estate agent of Bournemouth, stated that he was one of the earliest subscribers to the telephone exchange. He had not noticed that the telephone communication was worse after the electric light was introduced into Bournemouth than it was before that time. Mr. Alfred Vale, of Bournemouth, stated that the communication through his telephone had been imperfect at times, but he had not noticed any additional disturbance after the electric current had been turned on. The plaintiffs had filed affidavits in reply. Mr. James Swinburne stated that he went to Bournemouth on Wednesday, May 18th, and tested the various telephone circuits, and found the system very satisfactory. There was little or no cross talk. In some cases he thought there were some slight evidences of imperfect contacts, as men were at work on them, and had coupled them temporarily. The telephone system appeared to him to be admirable. He called up the electric light station No. 225, and found the circuit very good. When the defendants' electric current was turned on at eight o'clock he again listened to the various circuits which he had already tested, for there was a hum in all of them, undoubtedly due to the electric light circuits. In all cases, however, it was possible to speak without interruption. The noise was a drawback, and would interfere with conversation between ordinary subscribers, who were not accustomed to the use of telephones as he was, and cause annoyance. Mr. Charles Goldston, electrical engineer, and chief superintendent of the electrical telegraphs, telephones, and lighting of the South-Western Railway, also stated that he went to plaintiffs' telephone exchange on the 18th of May, and at once tried the working of many of the telephone lines. He found them free from disturbance at 3.20 p.m.; but at 8.15 p.m., after the defendants' current had been turned on he discovered a very considerable amount of humming noise on all of them. After having tried nearly the whole of the wires he came to the conclusion that it was caused by the defendants' current. The learned counsel stated that he had other affidavits to a similar effect. He submitted that it was useless to come to the Court for an injunction at all if defendants were allowed to go on creating a state of things which was worse than that which existed before the action was commenced. It would be seen from the affidavits, that the defendants did not deny that a disturbance existed, but they tried to minimise its extent. That question had been fairly dealt with by the evidence of the plaintiffs' experts, including that of Mr. Goldstone. It was true that the defendants had set up the opinion of Prof. Silvanus Thompson, but that gentleman was not everybody. He submitted that the evidence of plaintiffs' witnesses was quite as credible and weighty as that of Prof. Silvanus Thompson, whose idea of the necessity of a return wire was quite negatived by the plaintiffs' evidence. As regards the point that the injunction which had been granted extended to only overhead wires, he maintained that it applied to all wires, and asked that if his lordship was of opinion that the defendants had wilfully disobeyed the order of the Court he should grant the order for which he applied.

His LORDSHIP said he supposed the plaintiffs did not want the sequestration to go at once?

Mr. FARWELL replied in the negative. He said he only required it to hold over the defendants' heads. If, however, the defendants did not enable the plaintiffs to satisfy their subscribers within a short time, he should certainly ask his lordship to enforce it.

Mr. BYRNE, in opposing the motion, denied that the defendants had wilfully disobeyed the order of the Court. In reference to public undertakings of this nature, there were certain things to be observed arising under the Statute in regard to the regulations of the Board of Trade. Originally the defendants' wires were overhead, and then they were in this difficulty, that in order to comply with the Board of Trade regulations they had to put their wires underground. They obtained time to make the alteration, but the plaintiffs put great pressure upon them, with the result that they were obliged to work night and day to get the work done. He asked his lordship to look carefully at the evidence which the defendants had put in, and then say whether it could reasonably be contended that a nuisance was going on, and that it had been wilfully committed by the defendants.

His LORDSHIP said the defendants were restrained generally from causing injury to the plaintiffs' system. Of course the injury must be something appreciable.

Mr. BYRNE submitted that the nuisance must be something substantial.

His LORDSHIP said it occurred to him that there was something like an admission on the part of the defendants that owing to the haste and hurry in which they had been compelled to do their work, it had not been completed in the same manner as it would have been if there had been no such haste and hurry. Perhaps the defendants required a little more time.

Mr. BYRNE said the defendants' case was that there was no nuisance.

His LORDSHIP thought that there was evidence on the part of the plaintiffs that the defendants caused a disturbance even now.

Mr. BYRNE said there was some evidence, but he maintained that the evidence to the contrary by the defendants' witnesses was stronger. That, however, was not the point. He ventured to think that the point at issue was whether the defendants had been acting wilfully.

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His LORDSHIP suggested that if the defendants took a little more time they might satisfy the plaintiffs, and then the only question which would be left would be one of costs.

Mr. BYRNE asked his lordship to send down to Bournemouth an electrician of experience to examine the two systems, and to report to his lordship whether there was an appreciable annoyance, and, if so, what ought to be done by the defendants.

His LORDSHIP thought that the parties might agree upon an electrician who would make a report to him on the subject.

The case was accordingly adjourned *sine die*, to enable an electrician, to be agreed upon by the parties, to examine the plaintiffs' and defendants' systems and to report to the Court.

Clough and Co. v. The National Electric Supply Company.

This action was tried before Mr. Justice Day on Wednesday, in the Queen's Bench Division. It was to recover a sum of £120 for charges in connection with the obtaining of a loan of £5,000, acting as accountants, &c. The defendants paid £70 into court in settlement; but after hearing the evidence his lordship found for the plaintiffs with costs.

Akers v. Iliffe.

Before Justices Mathew and Wright, sitting as a Divisional Court, in the Queen's Bench, on Tuesday last, this action was tried. It was an appeal from a decision of Mr. Justice Denman, refusing to direct the plaintiff to give better answers to certain interrogatories in an action in which damages were claimed for alleged fraudulent representations in connection with the sale of an electrical business to the plaintiff for £5,000, the alleged misrepresentations consisting in the statements that the business carried on at Princes-street, London, W., was distinct from that carried on at Chalk Farm, London, N., and further that the net profits of the business for the year 1890 were £2,442. The defendant denied that such representations had been made by him, or by a Mr. Moat on his behalf. In the result the Court dismissed the appeal with regard to all the answers, excepting as to whether it was not a fact that the business at 17, Princes-street had been carried on since the purchase by the plaintiff, under the style of Charles Moat and Co., and as to the names of the partners in that firm.

CORRESPONDENCE.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is a great pity that members of the Institution of Electrical Engineers are practically unable either to read the Paper before it is formally read before the meeting, or to possess in their hands a copy of it during the time that it is being read. It is true there are some few proofs distributed before the meeting; but a great many members, who would otherwise take an intelligent interest in the business of the evening, are obliged to sit in uncomfortable and silent wonder owing to their being unable to gather the chief points of the Paper from the formal reading. The result is that the discussion severely suffers, and degenerates into a string of mere platitudes alternating with tangential flying into side issues. Members will not commit themselves to serious discussion or criticism till they have very much more information on the Paper than can be gathered from a single hearing. At the last meeting the discussion principally comprised a number of doubts as to whether the Newcastle Company can pay ten shillings a week or nothing at all for skilled management, and whether open-circuit transformers take more magnetising current than the closed-circuit ones (a question altogether at a tangent to the issues of the Paper). Many points of vital importance were entirely overlooked in the discussion, and presumably for the reasons I have already stated. Failing the confidence which is begotten of an intimate acquaintance with the Paper, I abstained from making a criticism, which I now beg the use of your columns to enable me to publish. On the wall near where I sat were a number of indicator diagrams from the Robey engines used at the Newcastle station, diagrams which plainly showed that there was something very wrong with the low-pressure valves of those engines. I gathered from the Paper, and have since verified, that owing to the irregular running of these engines the Mordey-Victoria alternators cannot be run in parallel; and that it is proposed to supply a more even torque to the pulleys either by means of a heavier flywheel or by running the whole power through springs placed between the shafting and the pulley! Now this would be clumsy, if not positively dangerous; and, in view of those indicator diagrams, is probably unnecessary. It is evident that there is a great deal too much compression in the low-pressure cylinders; there is, in fact, an enormous amount of over compression. Further than this, the steam is supplied to the low-pressure cylinders with too much wire-drawing. These defects are very noticeable at full load, but are even more so at light loads. I believe that if the Meye expansion valves on the low-pressure cylinders were reset so as to reduce the compression to at most one-third of what iti now, and if the steam were admitted with less wire-drawing there would be no difficulty whatever in getting the engines to run the alternators in parallel. I need not add that this would be a much more effective and economical mode of procedure than either of the ones suggested. One reason why the Robey engines at Newcastle are taking so much steam per unit supplied is because so much is wasted by inaccurate valve-setting. There may be losses in the transformers which are serious, and the low-tension system may or may not be more efficient, but in any system of distribution more energy is lost between the stoker's shovel and the dynamo pulley than anywhere else. One way to reduce these station losses is to look to the engine valves. That admirable engine-stethoscope, the indicator, often reveals malignant *consumption* in the lungs of the engine; and the only way to cure this expensive disease is to carefully reset the valves.—Yours, &c., E. T. CARTER.

29, Douglas-road, Willesden, N.W.
May 28, 1892.

ELECTRIC LOCOMOTIVES: A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A passage in the newly-published fourth edition of my "Dynamo-Electric Machinery" requires correction, being technically inaccurate. On p. 616 the statement occurs that the electric locomotives of the South London Electric Railway are now being replaced by some of Messrs. Siemens's locomotives. In justice to Messrs. Mather and Platt, it ought to be stated that the fourteen original locomotives supplied by them are still running, and that they have run in the aggregate not less than 450,000 miles. The two more recent locomotives supplied by Messrs. Siemens do not replace, but are supplementary to the original engines.—Yours, &c.,

June 1, 1892. SILVANUS P. THOMPSON.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Caledonian Railway Company invite tenders for various stores for twelve months from August 1st next. A list of these stores will be found in our advertising columns. Specifications and tender forms may be obtained on and after June 6th of Mr. J. Lorimer, Caledonian Railway Company, Charles-street, St. Rollox, Glasgow, where also patterns may be inspected. Tenders must be lodged with the Secretary, Mr. J. Blackburn, 302, Buchanan-street, Glasgow, not later than Monday, June 20th next.

——The Bristol Urban Sanitary Authority are inviting tenders for the supply, delivery and erection of condensers, pumps, steam and other pipes at their Electric Lighting Station, Temple-back, Bristol. Tenders have to be sent in by Friday, the 1st July next. Plans and sections of the Station may be seen at the offices of Mr. Henry Williams, 21, Clare-street, Bristol, and copies of specification and tender form at the offices of the Sanitary Authority, on and after Wednesday, June 8th. Mr. D. Travers Burges, of 51, Prince-street, Bristol, is Town Clerk. Further particulars are given in our advertisement columns.

——— The North-Eastern Railway Company invite tenders for the supply, for the six months ending December 31st, of telegraph apparatus and telegraph wire and line stores. Tenders must reach the Secretary by noon on Tuesday next, the 7th inst.

——— The Local Board of Bishop's Stortford invite tenders for lighting the public streets at present lighted for a year from August 16th. Tenders must be sent to Mr. W. Gee, the Clerk to the Board, not later than 10 a.m. on the 18th inst.

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TENDERS INVITED.—The Hull Corporation invite tenders for the supply of an overhead travelling crane for the electric light station. Tenders are to be in before noon on Friday next, the 10th inst.

——— The municipal authorities of Zamora, Spain, desire tenders for lighting the town by 100 20-c.p. and 220 16-c.p. incandescent lamps, and 14 1,200-c.p. arc lamps. Tenders to be opened on June 29th.

TENDERS ACCEPTED.—The tender of Messrs. Woodhouse and Rawson United, Limited, for wiring and fitting the Borough Surveyor's office at Huddersfield, has been accepted.

——— Messrs. Woodhouse and Rawson United (Limited) have secured the contract for supplying the machinery and plant for softening the water for the St. Helen's Corporation Waterworks. The amount of the contract will be £10,000.

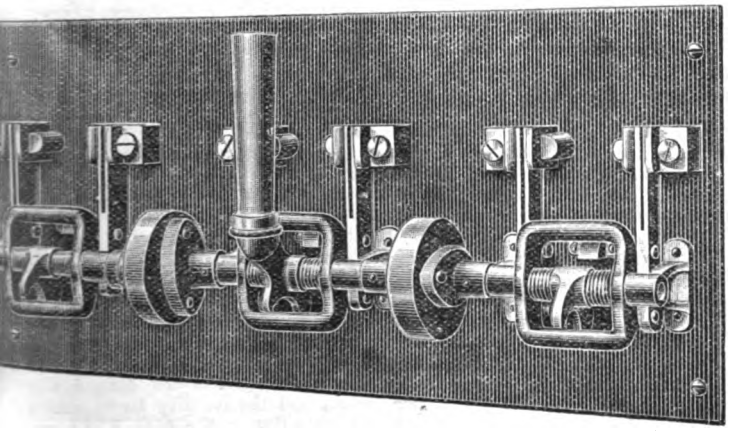
——— The tenders of Messrs. D. Hulett and Co. (Limited), Messrs. Evered and Co. (Limited), and the Phosphor Bronze Company (Limited) were amongst those accepted by the London County Council on Tuesday for the supply of brass and gun-metal goods and gas fittings for one year from the 1st prox.

APPOINTMENT VACANT.—The Gas Committee of the Manchester Corporation are prepared to receive applications for the position of clerk of the works, to superintend the construction and erection of the dynamos, engines, boilers, and other apparatus, and the laying of the mains and conductors, in connection with the electric installation. Applications must be sent in on or before the 24th inst. Particulars will be found in our advertisement columns.

DISSOLUTION OF PARTNERSHIP.—We are informed that the partnership hitherto existing between Messrs. E. H Cadiot and F. Espir has expired by effluxion of time. The business has been transferred to Mr. Fernand Espir, who will collect the whole of the assets and discharge all the liabilities of the late firm.

TELEPHONE AMALGAMATION.—The business of the Universal Telephone Company has been taken over by the National Telephone Company (Limited).

D. AND S. TRIPLE-POLE MAIN SWITCH.—A new form of main switch, to break three circuits simultaneously, has recently been introduced by Messrs. Dorman and Smith, of Manchester. This is illustrated herewith, and, as will be seen, consists of three of the double



Main switch for three-wire system.

break sudden-release B-type main switches, coupled together on an insulated shaft, and opened and closed by a single handle. The design is particularly strong, and there is no reason why these triple-pole switches should not meet with the success which has been met with by the double-pole design of a similar type.

MESSRS. CHARLES CHURCHILL AND CO. (LIMITED).—A handsome volume is to hand from this firm, containing illustrations, prices, and full particulars of their well-known American machine tools. The book forms a most complete catalogue; it contains many hundred illustrations, and consists in all of 320 large quarto pages. The book is prefaced by a complete index, and Messrs. Churchill and Co. intimate, in the introduction, that they will supply extra copies of any of the pages specially required.

ELECTRIC LAUNCHES ON THE THAMES.—We are asked by Mr. W. S. Sargeant to correct a statement made in our Trade Notes last week as to his being the builder of the electric launch "Myionu." Mr. Sargeant informs us that he designed and moulded the boat whilst acting as Manager for Messrs. Woodhouse and Rawson United (Limited).

MESSRS. WOODHOUSE AND RAWSON UNITED (LIMITED) have opened a branch for the Midlands at Minories, Birmingham, and have taken over the show rooms recently occupied by the Midland Electricity Company, together with the supply trade of that firm. We are asked to state that Mr. W. S. Sargeant has no longer any connection with this firm.

SALE BY AUCTION.—Messrs. James and Lister Lea and Sons, Birmingham, announce in our advertisement columns that they will sell by auction, on the premises, on June 20th to 24th, the valuable plant and machinery of Tranter's Gun Factory, Aston Cross, Birmingham, comprising 360 machines and lathes, steam engines, hydraulic tube drawing machine, a 50-ton Tangyes press, &c. They also announce that the works are to let.

WETLEY ABBEY, STOKE-ON-TRENT.—The Manchester branch of the Brush Electrical Engineering Company have put down plant for electric light at the residence of J. Hardman, Esq., which is noteworthy in that it demonstrates the success with which electric lighting can be carried out in a country mansion, with a petroleum engine as the prime motor. The plant consists of 60 16-c.p. lamps, with a battery of accumulators. A seven brake H.P. Priestman oil engine is used to drive a Victoria dynamo.

JOHNSTONE'S ELECTRIC CONDUITS.—We have received from the International Electric Subway Company (Limited) a copy of a pamphlet giving flattering testimonials to the value of the Johnstone system of electric conduits owned by that Company. The testimonials are chiefly from America, where the Johnstone system has been in use for some years, and where considerable satisfaction is expressed at the results obtained. This system was described in our issue of February 19th last.

THE MIDLAND ELECTRICITY COMPANY.—This firm will in future devote themselves exclusively to the development of the engineering and construction branch of their business.

HOTEL LIGHTING, &c.—The Great Northern Railway Company have recently purchased the Victoria Hotel, Bradford; and Messrs. Marsh, Jones and Cribb, of Leeds, who have the decoration and refurnishing in hand, have sublet the contract for the bell work and electric light to Messrs. Woodhouse and Rawson United, Limited. The current required is to be obtained from the Bradford Corporation Station.

LIGHTING OF OMNIBUSES.—The Lithanode and General Electric Company, working in conjunction with Messrs. Willing, have introduced a combined battery and electric lamp, which after three months' practical test is to be provided for the electric lighting of a complete line of road car omnibuses, superseding the oil or compressed gas hitherto used. The battery has five cells, and weighs about 15lb.

MR. R. G. IVEY.—Mr. Ivey has secured the contract for the electric lighting of Devonshire House, Bishopsgate-street, E.C., and also for the lighting of several business houses in Fenchurch-street.

COMPANIES' MEETINGS & REPORTS.

Reuter's Telegram Company (Limited).

The twenty-eighth ordinary general meeting of the shareholders of this Company was held on Wednesday, at the offices, 24, Old Jewry, "for the reception of a report and balance-sheet from the Directors, the declaration of a dividend, and the election of a director and auditors." Admiral the Right Hon. Sir J. C. D. Hay, Bart., K.C.B., presided.

The SECRETARY (Mr. Walter F. Bradshaw) having read the notice convening the meeting,

The CHAIRMAN said: I have now to move the adoption of the report. Before, however, making a few remarks on the operations of the Company during the past year, I think a few words of explanation are due to shareholders in reference to the delay which has occurred in holding the annual meeting. The 1st June is the regular date fixed by the Articles of Association, but in former years it has been found possible to complete the accounts by the end of April. This year, however, owing to the greater scope of our business, and the more complicated accounts we have to deal with, we have been obliged to revert to the original practice of holding the annual meeting at this period; and it may be a good opportunity to state, that in all probability, we shall not be able to submit the accounts at an earlier date in future. Turning to the profit and loss account, you will find that the revenue from the telegraphic business shows no retrogression. On the other hand, there has been a large increase of expenditure for telegrams and agencies. This increase occurred chiefly during the first half of 1891, when events of exceptional importance were happening in distant quarters of the globe, chiefly North and South America. The second half of the year has shown a very material improvement, which has been maintained up to the present time. In the opinion of the Directors, the results for the past year are satisfactory, taking into account all the exceptional circumstances with which the Company has had to contend. Without venturing to prophesy, we have good reason to hope that we shall this year earn a fair dividend and be able to strengthen the reserve fund, which I may remark, for the information of new shareholders, was primarily built up to equalise the dividend. The extraordinary, and I may add, not recurring expenditure, referred to in the

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report, comprises chiefly alterations to the premises, 24, Old Jewry, necessitated by the increased staff we have to employ, and also by the telephonic service between London and Paris. This service has involved important structural rearrangements, chiefly in order to secure a room impervious to outside sounds, as only the most expert telephonists are able to catch the sound of the voice coming over such a long distance. I may mention incidentally that 8,000 words were heard by our telephonists, and recorded within three quarters of an hour. The lease of No. 25, Old Jewry has been acquired for our advertisement business, which may be said to be still in its infancy. The legal formalities which had to be gone through before we could commence operations were only completed about the middle of last year, and since then, as you are aware, there has been considerable financial depression, which reacts immediately on advertising. We have not taken credit in the profit and loss account for any profit made under this head last year, but have applied it in reduction of the preliminary outlay incurred for the organisation of the new branch. We have every confidence that with a revival of financial and commercial activity advertising will prove a lucrative source of income to the Company. With these few words I now move the adoption of the report (in which a dividend of 5 per cent. was declared, free of income tax).

Baron GEORGE DE REUTER: I have much pleasure in seconding the motion.

The resolution was carried unanimously.

The Hon. MARK F. NAPIER afterwards proposed the re-election as a Director of Baron George de Reuter.

The CHAIRMAN seconded the resolution, which was carried unanimously.

On the motion of Mr. LOVEDAY, seconded by Mr. JOSEPH MOORE, Messrs. Welton, Jones, and Co. were re-elected auditors to the Company.

Mr. LOVEDAY then proposed a vote of thanks to the Chairman, Directors, and officials.

Mr. MOORE seconded the motion, which was unanimously adopted.

The CHAIRMAN: Gentlemen, on behalf of my colleagues and myself, I have to thank you very much for the vote of confidence you have been pleased to pass, and to assure you that we trust, now that we are in smoother water, that our duties may be less arduous. Whatever they may be, however, I hope that we shall continue to give you satisfaction, and the business of the Company that attention which it certainly deserves.

The proceedings then terminated.

The following is the report of the Directors of the Company:—

The Directors report that the net profits for the year ending December 31st last, after payment of current expenses, and deducting rebate on unexpired subscriptions, amount to £1,514. 6s. 10d., including the amount brought forward from the last account. In accordance with the Articles of Association, the Directors have charged extraordinary expenditure for alteration of premises, &c., to the reserve fund, and have transferred £3,000 to profit and loss account. From the amount thereby made available for distribution the Directors declare a dividend of 5 per cent., free of income tax, for the year 1891. This will absorb £4,415. 9s. 6d., and leave a balance of £98. 17s. 4d. to be carried forward. The dividend warrants will be payable on the 4th June. Baron George de Reuter retires from the direction, but offers himself for re-election. Messrs. Welton, Jones and Co. offer themselves for re-election as auditors.

Consolidated Telephone Construction and Maintenance Company (Limited).

The following is the Directors' report to be presented at the eleventh annual general meeting to be held at the Cannon-street Hotel, London, on Thursday next, the 9th inst., at 12 noon:—

The Directors submit to the shareholders the report and accounts of the operations of the Company for the year ended March 31, 1892, showing a net profit of £7,188. 4s. 8d., which, with the amount carried forward from last year, leaves a balance of £8,904. 9s. 6d. for disposal, after making provision for doubtful debts. The Directors propose to deal with the amount available as follows, viz.: to pay a further dividend of £1 per cent. for the half-year on the ordinary shares, and £3 per cent. on the preference shares for the half-year, making, with the interim dividend paid in November last, £6 per cent. for the year on the preference shares and £3. 10s. for the year on the ordinary shares; writing off the sum of £617. 4s. 10d. for depreciation of plant, machinery, and furniture; also £63. 16s. 8d. from cost of new building; thus leaving a balance of £1,366. 7s. 9d. to carry forward.

It is with regret that the Board find the figures for the year are not so satisfactory as on previous occasions. The falling off in the profit in manufacturing is owing to American, French, and German competition, the prices of our manufactures having had to be reduced to meet the demand for cheap goods, while the heavy duties placed on our instruments abroad have no doubt tended to reduce our sales in that direction. Every effort is being made to reduce the expenditure, both in the manufacturing department and in the office expenses. It will be seen that certain items of expenditure are charges on the present occasion, which will not recur.

On the result of the accounts being known, your Directors unanimously resolved to relinquish half of their fees for the year ending March 31, 1892.

Agencies for the sale of your manufactures have been established throughout the United Kingdom. The Company has also an exhibit of its manufactures at the Crystal Palace Electrical Exhibition, which is attracting a considerable amount of attention.

Your Directors are now engaged in organising a private wire telephone rental business. This fresh source of revenue will, they hope, be of a lasting nature.

The subsidiary Companies continue to make progress, as is shown by the following statement:—

	Year ending March 31st.					
	Paying Subs.		Rental.		Increase.	
	1891.	1892.	1891.	1892.	Subs.	Rental
Telephone Co. of Austria	3,263	3,588	£20,500	£22,500	325	£2,000
Anglo-Portuguese Telephone Company	2,074	2,139	£13,458	£13,640	65	£182
Total increase for the year...					390	£2,182

The Austrian Government have signed a contract with the Telephone Company of Austria for the purchase of that Company's exchange business, to take effect from the 1st January, 1893. The result to your Company will be the receipt of a large amount in repayment in respect of the securities we hold in that Company.

In accordance with the Articles of Association, the following Directors retire by rotation, and, being eligible, offer themselves for re-election, viz.: J. H. Buckingham, Esq., and Richard Van Zeller, Esq. The auditors, J. G. Griffiths, Esq., F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and A. E. Green, Esq., F.S.A.A., also retire, and offer themselves for re election.

Elmore's German and Austro-Hungarian Metal Company (Limited).

The Directors of the above Company have just issued their report for the fifteen months ending December 31st last. The report states that the negotiations for the purchase of land, buildings, and water power in Germany were completed on May 4th last year. The property is very valuable for the purposes of the Company. It is situated on the left bank of the River Sieg in Rhenish Prussia, about 40 miles from Cologne. An extensive factory had been partly erected by the previous owner of the property, and the Directors have since completed the building according to the special requirements of the Elmore process, which is capable of an output of from 10 to 20 tons per month. The original property included two turbines and gearing for utilising the water-power up to 550 H.P., which will be sufficient to work the factory up to an output of 80 tons per month. The cost of the whole property (lands, buildings, &c.), has been £22,000, which the report states has been valued by an official German valuer at £43,661, and a further sum of £6,610 has been spent on machinery, &c. Some difficulties have been experienced in obtaining legal possession of the property; and the Directors, therefore, in order to conform to the German law, decided to constitute a new Company (Elmore's Metall Actien-Gesellschaft), particulars of which were given in our issue of May 20th last. The Directors state that work has actually been commenced at the factory, and a delivery of goods has been made. Orders are coming in freely through the agency which has been established at Cologne; and the Directors anticipate that after a few weeks the factory will be fully at work, and have more orders than they can execute. The Directors have taken the necessary steps for working their several patents in Austria-Hungary; and the representative of the Company in Vienna is in negotiation with a firm of metal workers for working the Elmore patents under licence from this Company. With reference to finance, the Directors have thought it desirable in the interests of the Company to take steps with the view of relieving the pressure on its funds caused by the existing debenture stock, feeling that until profits are earned the interest amounting to £3,000 per annum and the liability there exists of repaying the capital sum by instalments during the next five years is a heavy charge upon the working capital. The result of negotiations is a proposal provisionally accepted by the principal holders of the debenture stock, by which the £50,000 of 6 per cent. debenture stock will be redeemed, and replaced by fully paid 7 per cent. preference shares; such shares to be entitled to further dividends *pro rata* after the ordinary shares shall have received dividends of 10 per cent. per annum. In order to enable the Board to accomplish this redemption of debentures, consent will be asked at the general meeting to the issue of preference shares to be exchanged for debentures. At the same time sanction will be asked to the issue of the 25,000 shares of the original issue, at present unallotted, either wholly or in part as preference shares, at the discretion of the Directors as to the time and manner of issue, for the purpose of providing additional working capital as may be required.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 302-322, *&c., &c.*]

ELECTRICAL INSTALLATION COMPANY (LIMITED).—This Company was registered on the 27th ult. with a capital of £1,800, in £1 shares. The objects are to carry on the business of electrical, mechanical, and hydraulic engineers in all their branches; to supply electricity for the purposes of light, heat, motive power, or otherwise; to construct, lay down, establish, fix, and carry out all necessary engines, dynamos, motors, cables, wires, lines, accumulators, lamps, and works; to generate, accumulate, distribute, and supply electricity; and to act as agents for the sale of

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electrical machinery and apparatus, and for any business connected in any way with electrical engineering. The signatories are:—

	Shares.
J. G. O'Brien, 2, Egerton-mansions, South Kensington	1
Edmond L. O'Brien, 6, South-street, Thurlow-square, S.W., electrical engineer	1
Mrs. J. G. O'Brien, 2, Egerton-mansions	1
Mrs. T. O'Brien, 6, South-street, Thurlow-square	1
Cuthbert E. Heath, Lloyd's, E.C.	1
Evan W. H. Fyers, 96, Eaton-terrace, electrical engineer	599
Capt. H. A. N. Fyers, 19, Onslow-gardens, S.W.	1

The first Directors are John G. O'Brien, Edmond L. O'Brien, and Evan W. H. Fyers, who are also the managers. Registered office: 1, Prince's-mansions, Victoria-street, Westminster, S.W.

VEALE AND CO. (LIMITED).—This Company was registered on May 26th, with a capital of £10,000, in £1 shares, by Crompton and Co. (Limited), Mansion House-buildings, London, E.C. The objects are to enter into and carry into effect, with such modifications (if any) as may be considered necessary, the draft contract already prepared in the name of the above Company, and made with Mr. John E. Veale, of St. Austell, Cornwall, for the acquisition by the Company of the business, machinery, stock and other property of the said Mr. J. E. Veale, and for the purchase by, and the transfer to, the Company of the Board of Trade licence to supply electricity in the Local Board District of St. Austell, Cornwall, and of the electrical installation and agreements in connection therewith, and to carry on the business of electricians, electrical contractors, suppliers of electricity for the purposes of light, heat, motive power or otherwise, and manufacturers of electrical apparatus. The signatories are:—

	Shares.
John E. Veale, St. Austell, electrical engineer	200
Arthur Coode, St. Austell	50
Thomas R. Bolitho, Penzance	50
William J. Lovering, St. Austell	50
John F. Albright, Mansion House-buildings, E.C., civil engineer	1
Carleton F. Tufnell, Lloyd's, E.C., civil engineer	1
R. E. Crompton, Mansion House-buildings, E.C., electrical engineer	1

ABELL'S ELECTRICAL ENGINEERING COMPANY (LIMITED).—An agreement, made the 7th ult., between Thomas K. Abell and William Hughes (the vendors), of the one part, and the above Company of the other part, determined that the Company should acquire the business of electrical engineers, colliery furnishers, and machinists which had for some time past been carried on by the vendors under the style of "Abell and Hughes," at the Steam Factory, Raglan-street, St. Helen's, Lancashire, and that the consideration for the said sale should be the sum of £650, to be satisfied as follows:—£50 in cash to Thomas K. Abell; £325 by the allotment to the said Thomas K. Abell of 65 fully paid-up shares of £5 each; and £275 by the allotment to William Hughes of 55 fully-paid shares of £5 each. The Company was registered on May 3, 1892, with a capital of £5,000, in £5 shares, with objects as stated above.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The annual return of the above-named Company, made up to May 18, 1892, was filed on May 24, 1892. The Company was registered on January 8, 1873, with a capital of £1,300,000, in £10 shares. At the time of making-up, the whole of the shares were taken up, the full amount called, and all calls (£1,300,000) paid.

EDISON GOWER-BELL TELEPHONE COMPANY OF EUROPE (LIMITED).—The annual return of the above-named Company, made up to April 14, 1892, was filed on April 19th following. The Company was registered on October 28, 1881, with a capital of £500,000, in £1 shares, to carry on the business of a telephone, telegraph, and electric light, heat, and power supply company; but the Company is not allowed to manufacture telephones or telephonic apparatus. At the time of making-up 385,009 shares had been taken up, of which 370,000 have been issued as fully paid. Upon the remaining 15,009 shares the full amount had been taken up, and, with the exception of £4, paid. The principal shareholders are the Consolidated Telephone Construction and Maintenance Company (209,994 shares), Theodore Paskas, Joshua F. Bailey, and George E. Gouraud (72,000 jointly), George E. Gouraud (94,996), Theodore Paskas (4,000), and Joshua F. Bailey (4,000).

ELECTRICITY SUPPLY CORPORATION (LIMITED).—An agreement made May 19, 1892, between the above-named Corporation of the one part and Agostino Gatti and Stefano Gatti of the other part, states that by a former agreement made May 18, 1892, between the same parties, it was determined that the Corporation should issue, and Messrs. Gatti should accept, such a number of ordinary shares in the Corporation as together with the shares already issued would make up the nominal amount of £50,000, and that the amount payable upon such shares should be retained by Messrs. Gatti on account of the indebtedness of the Corporation to them. At the time of the said agreement 359 shares of the nominal value of £10 each had been taken up, and therefore the number of shares required to make up the said nominal amount of £50,000 is 9,282 shares of £5 each. Messrs. Gatti have expended amounts far exceeding the £46,410, on behalf of the Corporation, and therefore the present agreement determines that the Corporation shall allot the said 9,282 shares to Messrs. Gatti or their nominees, numbered 719 to 10,000 inclusive, and that the sum of £46,410 payable in respect of such shares shall be retained by Messrs. Gatti on account of the indebtedness of the Corporation.

ELIESON ELECTRIC COMPANY (LIMITED).—This Company, which was registered on June 24, 1887, with a capital of £600,000, in £5 shares, has been dissolved. The last return, made up to December 31, 1890, and filed on May 21, 1891, showed that 31,185 shares were taken up, all of which were issued as fully paid.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED).—The annual return of this Company, made up to the 6th ult., was filed on the 18th. At the time of making up, all the shares had been taken up, and the 33,250 shares had been issued as fully paid in part payment of the purchase consideration. Upon the remainder the full amount had been called, resulting in the payment of £133,015. 6s., and leaving £484. 14s. in arrears, while £8 had been paid on 13 shares forfeited.

ISLINGTON AND GENERAL ELECTRIC SUPPLY (LIMITED).—The capital of the above-named Company has been raised from £800 in £5 shares to £250,000, by the creation of 49,820 shares of £5 each (filed May 21, 1892). *See* full prospectus in our last issue.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 16th, was filed on the 20th. The Company was registered on March 4, 1878, with a capital of £400,000 in £10 shares. At the time of making-up, 37,548 shares had been taken up, on each of which the full amount had been called, and all calls have been paid, while £8,000 has been paid on 800 shares forfeited.

MANLOVE, ALLIOTT AND CO. (LIMITED).—The annual return of the above-named Company, made up to April 9, 1892, has been filed.

MATHER AND PLATT (LIMITED).—An agreement made May 14, 1892, between William Mather and John Platt (the vendors) and the above Company states that the vendors have for some time past carried on the business of engineers at the Salford Iron Works, Manchester, and that the Company has been duly registered with the object, among others, of taking over and carrying on the said business. The present agreement, therefore, determines that the Company purchase (1) the goodwill of the said business, with the exclusive right of using the title of "Mather and Platt," and of representing that the Company is carrying on their business in direct continuation to that firm, together with the benefit of all existing patents, patent rights, licences, trade marks, and brands belonging to the firm of Mather and Platt; (2) all the lands, works, buildings, &c., and all fixtures; (3) all the plant, loose machinery, tools, utensils, stock-in-trade, book debts, chattels, and effects; and (4) all other property to which the firm of Mather and Platt may be entitled. The consideration for the said sale is £272,155. 17s. 4d., satisfied as follows:—£100,000 by the issue of 1,000 debentures of the Company for £100 each (to be a first charge on the entire assets of the Company, including its uncalled capital for the time being), carrying interest at £5 per cent. per annum, the principal to be repayable on January 1, 1902, with power for the Company to redeem part or all such debentures at £105 per cent. at any time after a notice of six months; £135,000 by the allotment of 15,000 shares in the Company, upon each of which the sum of £9 is to be credited as having been paid up, and by the payment of the balance (£37,155. 17s. 4d.) in cash. The purchase is to be considered as having been made on and to take effect as from January 1, 1892, and was, at the time of the signing of the agreement, about to be completed on June 1, 1892, when the Company was to pay the said £37,155. 17s. 4d. in cash to the vendors, or as they directed. The second schedule to the above mentioned agreement details the purchase consideration as £41,991. 5s. 8d. for the trade debts and trade contracts, and £41,449. 12s. 11d. for the patents and goodwill.

MISCELLANEOUS.—CYNON (ABERDARE) TIN PLATE COMPANY (LIMITED), tin plate manufacturers, mechanical and electrical engineers, &c.; capital £15,000, in £100 shares.——JOHNSON'S PATENTS (LIMITED), mechanical and electrical engineers, &c.; capital £40,000, in £10 shares.——SCOTTS, ENGINEERS (LIMITED); capital £20,000, in £1 shares.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend of 3s. per share, free of income-tax, for the quarter ended March 31st last, and payable on the 24th inst. The transfer books of the Company will be closed from the 17th to the 23rd inst., both days inclusive.

CAMBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).—The prospectus of this Company has just been issued. It has been formed for the purpose of taking over from Messrs. C. A. Parsons and Co. the powers granted by the Provisional Order obtained by the Corporation, enabling them to supply the electric current within the borough. The capital is £50,000, in £10 shares, payable, £2 on application, £2 on allotment, and the balance (up to £8) by instalments of £2 at intervals of not less than one month. It is expected that current will be turned on in October next, and the prospectus states that the results of canvasses made satisfies the Directors that they will commence operations with a good prospect of success. The Directors include Sir B. C. Browne, D.C.L., and Mr. J. B. Simpson, Directors of the Newcastle and District Electric Lighting Company (Limited); and the Hon. C. A. Parsons, the managing director, is also managing director of the last-named Company.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 29th were £713, as against £768 for the corresponding period of last year, being a decrease of £55. The total receipts to date, from January 1st last, amount to £17,409, against £16,143 in the corresponding period of 1891, being an increase of £1,266.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of May were £3,600, as compared with £3,633 in the corresponding month of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the month of May amounted to £54,842, against £53,829 in the corresponding period of 1891, being an increase of £1,013.

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EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of May amounted to £40,612, and to £37,064 in the corresponding period of last year, a decrease of £3,548.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—It is announced in our advertisement columns that the transfer books and register of members were closed on the 25th ult., and will remain closed until the 7th inst. inclusive.

INDIA-RUBBER, GUTTA-PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).—Application has been made to the Stock Exchange to grant a special settling day in and to grant a quotation to the further issue of 8,400 shares, Nos. 41,601 to 50,000.

NEW YORK BELTING AND PACKING COMPANY (LIMITED).—At the first ordinary general meeting of this Company, held at the Cannon-street Hotel on Saturday, the Chairman (Mr. Samuel Pope, Q.C.), said that the business was, in the judgment of the Directors, healthy, and likely to be prosperous. Dividends of 10 per cent. on the ordinary, and 8 per cent. on the preference shares, were declared.

ORE DRESSING AND GOLD EXTRACTION COMPANY (LIMITED).—The fifth ordinary general meeting of the shareholders in this Company, formed for the purpose of amalgamating the working of the two processes for ore dressing and gold extraction—the Newbery-Vautin and the Lubrig—was held on Tuesday, at Winchester House, Old Broad-street, under the presidency of Mr. F. Thorne, when the report and accounts were adopted.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended May 27, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,449.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 25.	Price Wednesday, June 1.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 1. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,98(	Stock	12/6	Anglo-American	48 49	48 49	5 12 3	Jan., Apr., July, Oct	49	48
£2,849,51(	Stock	25/0	Do. Preferred	88 89	88½ 89½	5 17 4	" "	89½	88
£2,849,51(	Stock	5/0	Do. Deferred	11¼ 11¾	11¼ 11¾	..	" "	11 7/16	11¼
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	101 104	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½ 11	10¼ 10¾	7 8 10	Mar., June, Oct., Dec	10¾	10 7/16
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	105 109	4 11 9	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	158 163	158 163	4 5 11	Jan., Apr., July, Oct.	160½	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3¾	3¼ 3¾	6 18 8	April and October..	3¾	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11¼ 11¾	11¼ 11¾	5 19 2	Jan., Apr., July, Oct	11 7/16	11 5/16
400,000	10	2/6	Eastern	14¼ 15	14¾ 15	4 6 8	" "	14¾	14 5/16
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15¾	15½ 15¾	3 16 2	" "	15¾	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	109¼	109
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	107 110	4 11 9	February & August	108	..
250,000	10	6/6	Eastern Extension	14¾ 15¼	15 15½	4 11 10	Jan., Apr., July, Oct.	15½	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 1	February & August	109¼	109
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	101 104	3 16 11	February & August	101¾	..
180,227	10	2/6	Globe Telegraph and Trust	10½ 10¾	10½ 10¾	5 0 0	Jan., Apr., July, Oct.	10 7/16	10 5/16
180,042	10	6%	Do. 6 per Cent. Preference	15¾ 15¾	15¾ 15¾	3 18 1	" "	15¾	15¾
150,000	10	7/2	Great Northern	18¾ 19¼	18¾ 19¼	4 9 2	Jan., April, and July	19¾	19
£790,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	108¼	107½
17,000	25	37/6	Indo-European	40 42	40 42	5 19 1	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	6½ 7½	7 8	5 6 11	April and October..	7¾	..
3,381	£100 Cert.	£1¼	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	101½	101
30,000	10	2/0	West Coast of America	3¾ 4¼	3¾ 4¼	5 11 1	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama xd	1¼ 1¾	1¼ 1¾	..	" "	1 5/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference xd	10 10¾	9¾ 10¼	5 17 1	May and November	9¾	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref. xd	9 10	8 9	6 13 4	" "	..	..
67,007	15	6/0	Western and Brazilian xd	9¼ 10	9¼ 9¾	6 3 1	" "	9¼	9¾
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred xd	6 6¼	6 6¼	5 15 3	" "	6¼	..
30,364	7½	7/6	Do. 5 per Cent. Deferred xd	3¾ 4	3¼ 3¾	..	" "	3 7/16	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105 108	106 108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105 108	105 108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	115 119	115 119	5 17 8	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
£24,850	14/0	4·094	Consolidated Telephone Const. & Maintenance	⅜ ⅝	⅜ ⅝	6 10 10	May and November	..	..
£20,000	£1	4½d.	Oriental (11s. paid)	1 1/16 1 3/16	1 1/16 1 3/16	6 8 11	Yearly	..	..
£38,984	5	2/6	National	4¼ 4½	4⅜ 4⅝	6 3 1	June and December	4⅝	4 7/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13 13½	13½ 13¾	4 7 3	" "	13 7/16	13½
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12½ 12¾	12⅝ 13	4 12 4	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	107 109	108 110	4 1 10	January and July ..	108½	106½
58,000	5	1/0	United River Plate	1½ 2½	1½ 2½	..	" "	1¾	..
£146,870	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£8 paid)	7¾ 8¼	7¾ 8¼	..	..	8 1/16	7¾
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	.. ..	2½ 3½	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	.. ..	.. ..	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 1/16 3 3/16	3 1/16 3 3/16	..	March	..	..
10,030	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	½ 1	½ 1	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	7½ 8	7½ 8	..	..	7⅞	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5	4 5	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8½ 9	8½ 9	..	..	8 1/4	..
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	..	..	8 1/16	8 1/16
42,853	5	..	Westminster Electric Supply (fully paid)	6½ 7	6½ 7	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/0	Brush Electrical Engineering	3 3½	2¾ 3½	..	..	3½	3
69,996	2	6%	Do. 6 per Cent. Preference	2 2½	2 2½	5 2 7	..	2¼	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5¾	5½ 5¾	5 16 8	January and July ..	5 1/8	..
17,180	5	17%	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	12/0	Electric Construction	5¾ 6¼	5½ 6	..	..	6	5¾
70,000	2	10/0	Elmore's Patent Copper Depositing	2¼ 2½	2⅝ 2⅞	..	..	2 1/8	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½ 20½	19½ 20½	6 1 11	February & August	20½	20
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 105	102 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1/16 1/16	⅛ ⅜	..	..	..	..
78,949	5	2/9⅓	Swan United (£3. 10s. paid)	3½ 4	3½ 4	9 13 0	May and November	3¾	3⅜
36,250	12	36/0	Telegraph Construction and Maintenance	42 44	44 46	5 4 9	March and July	45½	43⅜
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	103 106	4 14 4	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	.. ..	½ ¾	..	..	..	..
..	£5	8%	Do. Preference (fully paid)	.. ..	2½ 3	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
50,000	£10	..	City and South London Railway	2½ 3½	2½ 3½	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

The subject of nomenclature attracts attention at every Electrical Congress, and, in view of the approaching Exhibition at Chicago, M. Hospitalier, who has always shown exceptional interest in this matter, has recently expressed some opinions which will meet with general approval. It will be seen from the printed account, published in another column, that M. Hospitalier advises that the introduction of new names should be avoided wherever simple compound words can be found the meaning of which is self-explanatory. In this opinion we quite concur. The names of Joule and Coulomb are not commonly used to express the units of electrical energy and quantity, in spite of the advocacy of scientific men. The far more expressive names of watt-hour and ampere-hour have been found the fittest to survive. In the naming of new units this example should be borne in mind. It is impossible to honour all first-class electricians in the graceful manner originated by the British Association. The fundamental units had, of course, to be named in some arbitrary fashion, and the method adopted was the best that could have been chosen. A derived unit should, however, show its meaning by the way in which its name is built up, wherever this can be done without forming a compound word which is either too long or too difficult to pronounce.

The sentiments expressed by the promoters of the modified form of copper "corner," which is to commence its beneficent operations on July 1st, are in every way admirable. There is no intention, we are told, of unduly putting up prices, and trade is to be in no way inconvenienced; what is aimed at is merely a stoppage of the too keen competition which has obtained of late among copper producers. We seem to have a dim recollection of having heard this tale before. The difference between £45. 10s. per ton, the average price for the past five months, and, say, £60 may possibly be thought by no means an *undue* elevation; nevertheless, it is to be remembered that every one of the 3,480 pennies will have to come out of the copper consumer's pocket. However, the excellent intentions of the promoters of the scheme, supplemented by reminiscences of the fate which befell the 1888-89 corner, will tend to moderation.

The carbon submarine cable relay devised by Mr. Charles Cuttriss, of the Commercial Cable Company, a description of which will be found in this issue, is a very ingenious arrangement, which will no doubt answer within the limits mentioned. Dr. Alexander Muirhead and Mr. H. A. C. Saunders, of the Eastern Telegraph Company, were working in this direction more than ten years ago, and took out a patent covering the use of the variable resistance of selenium cells for attaining their object; but they could not get these cells to answer. We may mention that Allen and Brown's relay, to which reference is made by Mr. Cuttriss, has worked at the rate of 28 words per minute with the Saunders curb key through 620 miles of cable with the current sent by 14 volts, while with a recorder form of coil it would do much more.

When electric motors really come into use in this country otherwise than as rival attractions to frying-pans at Electrical Exhibitions, the question of the most useful size for certain work will be very important. Machine tools, lathes, drills, &c., may be run by separate motors as at the Elwell-Parker works at Wolverhampton; and a loom may be worked in a similar manner, as has been done by Mr. Livesey at Blackburn; with greater economy than the driving of each line of shafting in a factory by a large motor. But in cotton spinning a high speed is used at the spindles, and with ball bearings it is said that 16,000 revolutions per minute may be reached. Such speeds as this are admirably suited for electrical transmission, but the first cost of a small motor for each spindle would be prohibitive, even if long multiple field magnets were arranged to take a number of armatures. The power used in spinning varies from one-thirtieth to one-five-hundredth of a horse-power per spindle; and as rather more than a thousand spindles go to a mule in modern work, there is ample choice for the electrical engineer between one motor for each mule, or smaller ones at higher speeds mounted on the carriages and driving the tin rollers direct. It is probable that fully one-third, if not one-half, of the power is spent at present upon friction of shafting, &c., and nearly all this might be saved by applying small motors direct to the work.

Whether the public has become accustomed to delays or whether things are really going more smoothly we do not know; but, at any rate, comparatively little is now heard about breakdowns on the City and South London Railway. As in all cases where authentic information is not forthcoming, the quidnunc has been at work. The locomotives supplied by one firm we are told are electrically weak, while those supplied

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by another are mechanically defective, and so on. There are always good reasons for reticence in these matters. Those responsible for the working of a new concern like the City and South London line naturally do not care to parade its failings too prominently. Contractors and designers of machinery dislike what they consider to be the captious comments of arm-chair engineers, and are moreover disinclined to place gratuitously at the disposal of their trade rivals practical knowledge which it has cost much to attain. Nevertheless, it is impossible not to regret in the interests of the electric traction industry at large that there should be so much mystery about so simple a problem, and so much sensitiveness in regard to honest and competent criticisms.

It would be in the highest degree detrimental if the mishaps which have occurred South of the Thames were repeated on the northern bank; an untoward consummation which a plain straightforward engineering account of the first year's working of the line, such as was recently given to the Institution of Electrical Engineers in connection with the electric lighting of Newcastle, would go a long way to obviate. A perfect "loco" motor no more than anything else of the kind springs straight from the designer's brain. That the City and South London Railway is, on the whole, a distinct electrical success is amply proved by the evidence before the recent Select Committee. Not one of the many opponents to the new schemes ventured to deny it.

The report upon the proposed Mechanical Sciences Tripos at Cambridge, of which we print an abstract this week, has to be discussed in the "Arts School," and a "grace" giving effect to the recommendation will then be offered to the Senate, and, if approved, the Tripos will be established. The discussion will not take place until Michaelmas Term next. We hope to comment on this important departure on an early occasion.

Electric Traction in France. — The Marseilles-St. Louis trolley line came into regular operation on the 22nd ult.

Royal Society Conversazione.—The second *conversazione* of the Royal Society will be held on Wednesday, June 15th.

Telegraphs Bill.—This Bill was read a second time in the House of Commons on Friday last, and referred to a Select Committee.

The New Telephone Company's Bill.—The order for the second reading of this Bill was discharged and the Bill withdrawn last Thursday.

H.M.S. "Royal Sovereign."—There are no less than 800 electric lights and 30 miles of electric wire on board this latest addition to our fleet of battle-ships.

Armoured Cables.—According to *L'Electricien*, Siemens and Halske's German patent for electric light cables sheathed with iron strip has been declared invalid.

Interurban Telephony.—On Friday last the Director-General of Posts and Telegraphs opened the telephone lines between Paris and Antwerp, and Rheims and Charleville.

Institution of Electrical Engineers' Conversazione.—The *conversazione* of the Institution of Electrical Engineers will be held on Friday, July 1st, in the galleries of the Royal Institute of Painters in Water Colours.

The Salomons Scholarship.—Mr. C. H. C. Woodhouse, Second Year Matriculated Student Electrical Engineering Department City and Guilds Central Institution, Associate Royal College of Science, B.Sc. London University, has been awarded the Salomons Scholarship, value £35.

Lightning.—A Reuter's telegram from Vienna states that great destruction was caused by a violent thunderstorm which passed over the Alpine districts of Lower Austria on Saturday evening last. According to a despatch from Gratz, an isolated cottage at a place called Gamin, near Thormauern, was struck, and its eight occupants killed. The cottage was set on fire by the lightning.

St. Pancras Vestry Electricity Supply.—A paragraph has been going the round of the papers to the effect that the St. Pancras Vestry is supplying current at the abnormally low price of 3d. per Board of Trade unit. Some qualification of this statement is, however, needed. The Vestry supply current either for lighting or motive power *during the day* at 3d., but the price of the night supply is 6d.

The Société Française du Télégraphe de Paris à New York.—The shareholders of the Société Française du Télégraphe de Paris à New York, between whom and the Board of that concern there is a coolness, recently held their annual general meeting without a single member of the Board being present. The *Bulletin International de l'Electricité* remarks that it is not stated whether the shareholders voted themselves a dividend.

The Paris-Bordeaux Telephone Trunk Wire.—*La Lumière Electrique* gives some interesting particulars with regard to the cost of this line of 360 miles, which came into operation on Wednesday. The total cost of the line has been £26,000, which will be repaid by the State out of the profits accruing. The Bordeaux Chamber of Commerce subscribed £16,800, and that of Paris £5,200; to this sum £4,000 was added by the Bordeaux Municipality.

An Extraordinary Accident.—A Reuter's telegram dated New York, May 28, is responsible for the following:—An extraordinary accident occurred to-day at the Edgar Thompson steelworks at Braddock, Pennsylvania. A number of men were working on a travelling crane in the blacksmiths' shop when the boom came in contact with an electric light wire and cut through the insulation. Instantly the force of the current passed down the iron framework of the crane. All the men at once fell to the ground insensible, and two of them were killed.

Electric Lighting Provisional Orders.—The following Electric Lighting Provisional Orders have been granted by the Board of Trade this Session, and Bills to confirm them have been introduced into Parliament:—Aberystwyth, Ashton-under-Lyne, Dublin, Fareham, Govan, Halifax, Harwich, Kilkenny, Limerick, Liverpool, Maidstone, Newbury, Oxford, Sheffield, Sutton (Surrey), Waterford, West Ham, Woking Electric Supply Company's (Horsell and Chertsey) Order, Southwark, Wandsworth, Hampstead, Lambeth, Shoreditch, and Whitechapel. In all 24 orders have been granted, as against 58 last year.

Electric Lighting at Cable Stations.—The large station of the Commercial Cable Company at Waterville, County Kerry, has recently been lighted throughout with electric light under the supervision of Mr. J. A. McMullen. Coal being expensive and difficult to obtain in the neighbourhood, a 9 H.P. Priestman petroleum engine has been used with great success. Eighty 16 c.p. lamps have been fitted in the offices and the dwelling quarters of the staff. The dynamo and engine are supplemented by a battery of E.P.S. cells. The Canso (Nova Scotia) station of this Company has been lighted for the past year by electricity, which is a great boon to the staff. The lighted station also serves as a landmark for coasting vessels at night.

The Purification of Sulphuric Acid for Accumulators.—As will be seen by Dr. Kugel's article in another column, metallic impurities in the electrolyte are considered by him to play a very important part in diminishing the capacity of secondary cells. Now these deleterious metals are completely precipitated in a dilute sulphuric solution by sulphuretted hydrogen; and Dr. Kugel utilises this fact to purify acid intended for accumu-

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lators. A current of the gas is passed through the electrolyte, which is then filtered after four-and-twenty hours' rest. When this process of purification is carried out alone it is preferable to generate the sulphuretted hydrogen within the acid itself, by treating it with baric sulphide. This method has been employed by Herr Lucas at Hagen.

Exeter.—At Wednesday's meeting of the City Council the lighting of the city came up for discussion. Communications from the Gas Company stated they were prepared, under a seven years' contract, to supply improved lamps at cost price, and provide gas at 2s. 9d. per thousand cubic feet, and for large special lamps in the open spaces at 2s. 6d. per thousand. A memorial signed by about one hundred ratepayers in the principal streets asked that electric light might now be provided. Alderman Willey considered the question required further looking into, and moved that the correspondence be referred to the Lighting Committee, who should be asked to report on the relative cost of the two systems. This was agreed to after some discussion.

The St. Clair Tunnel.—"Great trouble," says *Engineering*, "is being experienced in ventilating the St. Clair Tunnel, which passes under the Detroit River, and is one of the principal connecting links between the railway systems of the United States and Canada. The ventilation is said to be so bad that difficulty is found in obtaining drivers willing to run the engines through it. Owing to the steep grades, very heavy engines are used for working the tunnel section, and these engines turn out large quantities of smoke and products of combustion. Smoke consumers are to be fitted to the engines with a view of mitigating the nuisance. The tunnel was opened only last year." This would seem to afford another opportunity for the Edison-Thomson-Houston Company to advertise the capabilities of large electric locomotives.

Niagara and Electricity.—Under this heading Prof. George Forbes contributed a column-long letter to *The Times* of Wednesday, describing the operations of the Cataract Construction Company, an illustrated account of which appeared in *The Electrician* of December 5, 1890 (Vol. XXVI., page 144). The intake canal, 1,500ft. long, at right angles to the river, has been cut. The vertical shaft, 140ft. deep, is being sunk, and from the lower level the tunnel, 28ft. high and 18ft. wide and 6,700ft. long, has been carried at a slope of 7 per 1,000, to issue at the foot of the cliffs below the falls, just under the suspension bridge. This work is all nearly completed. The lining of the tunnel with four courses of bricks is going on at the rate of 100,000 a day, and this rate is about to be increased. The turbines are in hand. Part of the power is to be used in factories now being built directly over shafts.

The Patent Office.—According to the ninth report of the Comptroller-General of Patents recently presented to Parliament, 22,888 applications for patents were made last year, against 21,307 in 1890, and 17,110 in 1884. The figures for 1891 show an increase of 7½ per cent. over those for 1890. The total income of the Patent Office from all sources during 1891 amounted to £203,520, of which £181,777, or 89 per cent., accrued from patent fees. The total expenditure during 1891, including £21,703 devoted to new buildings, amounted to £103,180, leaving a surplus of £100,339. Out of the total expenditure £54,267, or nearly 53 per cent., went in salaries and wages to the Patent Office staff. The number of readers at the Patent Office library during the year amounted to nearly 100,000. The total number of registered patent agents is now 236, five names having been added during 1891.

Personal.—Mr. W. B. Esson has resigned the position of manager and electrician to Messrs. Paterson and Cooper, which he has held for nearly nine years.—Mr. E. H. Taylor has been appointed sole agent for Brazil of the Brush Electrical Engineering Company.—Mr. Douglas Wells, superintendent of telegraphs, and engineer to the Colony of the Bahamas, also consulting engineer and electrician to the Colonial Government, has resigned these positions. Mr. Wells, who we may mention laid the Bahamas-Florida cable between Nassau and Jupiter, successfully established the system of working direct to Jacksonville, Florida, through 211 knots of cable and 405 miles of land line, using the American closed-circuit system with great success, a speed of 35 words a minute being obtained between the two places. There are seven small stations between Jupiter and Jacksonville. With the exception of the Havana cable this is the only submarine cable working on closed-circuit system using sounders.—Mr. Percy Still has been appointed resident engineer to the Chelsea Electricity Supply Company.

Greenwich Observatory.—On Saturday last the annual visitation of the Board of Visitors took place at the Royal Observatory. The Astronomer Royal stated in his report that the Admiralty had authorised the erection of the south wing of the proposed Physical Observatory during the present financial year. During the year ending 1892, May 10th, photographs of the sun were taken on 219 days. The solar activity had increased, it was stated, in a remarkable manner during the past year. The question of the association of magnetic disturbances with sun spots was of great interest. It appeared from the Greenwich records since 1873 that most of the magnetic storms occurred when an exceptionally large spot was visible on the sun near the centre of the disc, or about the time of some great change in a sun spot; also that magnetic storms were generally characterised by a sudden initial movement of the magnets, simultaneous in all parts of the earth. In connection with the magnetic department, attention was drawn to the fact that the passage of trains on the electric railway 4½ miles from the Observatory seriously disturbed the instruments.

The McKinley Tariff and Submarine Cables.—We are confident (says a New York paper) that a recent importation of dutiable merchandise at Jupiter, Fla., has not escaped the vigilant eye of Assistant-Secretary Spaulding, who writes the decisions in which the Treasury Department interprets and applies the provisions of the McKinley tariff. We refer to the landing at Jupiter of the American end of the new telegraph cable from Nassau. The law with respect to imported goods of this kind has already been interpreted and applied by Mr. Spaulding. As soon as the American end of the telephone cable from the Canadian town of Windsor emerged from the water at Detroit a few months ago, the watchful Assistant Secretary promulgated a decision that it was clearly dutiable and must be taxed under the law of McKinley. The decision has been published by the department, and, so far as we know, has never been reversed. The American end of the Nassau cable was landed at Jupiter on Saturday last, and the British steamer "Westmeath," after doing the work, slipped away in the darkness of the following night. The protruding end of this cable should be appraised at once, and the full duty should be exacted.

Copper.—We are authorised to state, says the *Statist*, that an understanding has now been arrived at between the American and European producers of copper in regard to the production of the metal for the twelve months from July 1st next. With regard to the above, says our contemporary, we believe that the arrangement is to the effect that the European Companies are to reduce their output by 5 per cent., and that the American Companies are to restrict their exports to Europe. What is aimed at, it will be seen, is a moderate reduction in the production; or rather, perhaps, it would be more correctly described as a stoppage of the too keen competition between producers which has been going on lately, and a reasonable attempt to regulate supply to demand. We understand that there is no intention to put up prices unduly, or in any way to inconvenience the trade. There is to be a committee elected to carry out the arrangement. Each of the Companies will, of course, raise their selling prices, but they will raise them moderately. Two years ago the visible supply was, approximately, 82,000 tons; it is now down to below 54,000 tons. The average prices for the calendar years 1889, 1890, and 1891 for Chilian bars were, respectively, £49. 10s. 6d., £54. 5s., and £52. 9s. 8d. The approximate average price for the past five months has been about £45. 10s.

A Proposed London County Council Electric Railway.—A proposal for the construction of an electric railway to be paid for on the betterment principle has been put on the County Council programme by Mr. Saunders for discussion at an early date. Not long ago the Chairman of the Great Eastern Rail-

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way said that a fare of twopence for a journey from Enfield to Liverpool-street and back remunerated his Company if there were 500 passengers in the train. This being so, Mr. Saunders concludes that on the electric railway line, the interest on the cost of which would be paid by the improved value of the land, a penny fare for twenty miles would pay, seeing that electric trains are smaller and cheaper than the trains run by the Great Eastern Company. His motion, therefore, will be—"That the Council do instruct an experienced railway engineer to advise it as to the best route for an electric railway, passing underground through Whitechapel, rising to the surface at suitable points, and extending about 20 miles north and south from the centre of the railway at Whitechapel; this advice to be obtained with a view to preparing plans and estimates and submitting to Parliament a scheme for the construction of such a line. The cost to be paid by the application of the betterment principle to the increased value of land imparted by the railway. Workmen's trains to be provided at a net charge not exceeding sixpence per week for travelling ten miles daily and return."

Conference of Telegraph Clerks.—The annual conference of the Postal Telegraph Clerks' Association was opened on Saturday, at the Cannon-street Hotel; Mr. A. W. North, of the Central Telegraph Office, presiding. The attendance at the conference was the largest on record. After prolonged discussion, the following resolution was passed:—"That this conference respectfully calls upon the Postmaster-General to remove the existing restrictions upon the political and civil rights of the officers of this service, and especially calls upon him to grant the right to hold meetings for the discussion of questions of interest to the staff without departmental interference." A resolution dealing with the scale of salaries and in favour of the abolition of classification was carried unanimously. It was then moved:—"That, having regard to the rapid increase of female labour throughout the Service, it is in the opinion of this conference most essential that a limit should be placed upon such labour." But a motion that it was inexpedient to discuss the question of female labour was ultimately put and carried by a large majority. Resolutions relating to errors in telegrams, sick pay, and the "Raikes" scheme were also carried. A resolution was also adopted to the effect that it was advisable that a greater proportion of postmasterships should be given to members of the Telegraphic Service. Cardiff was chosen as the place of meeting next year.

The Chicago Exhibition Incandescent Lighting Contract.—We are informed by the Westinghouse Electric Company (Limited), of 32, Victoria-street, that they have received a communication from the Vice-President and General Manager of the Westinghouse Electric and Manufacturing Company of Pittsburgh, Pa., U.S.A., to the effect that that Company has been awarded the contract for the incandescent lighting of the Chicago Exhibition after severe competition. The contract covers apparatus to the extent of about 90,000 16-c.p. lamps. According to the *Western Electrician* of May 28th, the contract price is $399,000, which works out at under $4\frac{1}{2}$ per lamp, as against the last Edison-Thomson-Houston figure of $5.95 per lamp. The first bid was at the rate of $18 50 per lamp. "It cannot be asserted, however," says our Chicago contemporary, "that the action of the committee is entirely conclusive; for if anything has been developed in the strenuous contest of the last eight weeks, it is the fact that the result is never certain until the contract has been actually signed. . . . The competition for the contract has been very keen, not to say bitter, and the contest will become a memorable one in an industry noted for active business rivalries. Neither side can boast that its procedure has been above criticism, and there is not a little, taking the conduct of the negotiations from first to last, that the electrical fraternity will look back upon with regret, and which will not add to the reputation of the industry before the people." The actual signing of the contract depends on the condition that Mr. Westinghouse shall, on or before to-day, June 10th, execute a bond in the sum of $1,000,000 that he will faithfully carry out the provisions of the contract.

Institution of Civil Engineers.—At the annual general meeting of this Institution on Tuesday, May 31st, it was stated in the report of the Council that the additions to the register together amounted to 366; and after deducting 145 names from deaths, resignations and erasures, there was a net increase of 221, bringing up the total number on the register to 5,371, as against 5,150 at the corresponding date last year. This enumeration was irrespective of students. During the financial year ending March 31, 1892, the total receipts amounted to £26,188. The Council awarded a George Stephenson Medal and a Telford Premium to Mr. Alex. R. Binnie; Telford Medals and Telford Premiums to Mr. A. P. Trotter and Mr. W. T. Douglass; and Telford Premiums to Messrs. H. Alfred Roechling, A. H. Curtis, W. Airy, H. Gill, and Prof. W. C. Roberts-Austen. In respect of communications received and not discussed, Telford Medals and Telford Premiums were adjudged to Messrs. F. Fox and Alfred W. Szlumper; and Telford Premiums to Mr. Sheibner, Profs. T. H. Beare and W. C. Unwin, and Messrs. E. Penny, A. D. Stewart, R. H. B. Downes, and W. Matthews. The Howard Quinquennial Prize was awarded to Sir Isaac Lowthian Bell, F.R.S., for his treatise on "The Principles involved in the Manufacture of Iron and Steel." A Miller Prize was awarded to Mr. C. H. Wordingham, Stud.Inst.C.E., for his Paper on "Meters for recording the Consumption of Electrical Energy." The following is the Council for the ensuing year:—President: Mr. Harrison Hayter. Vice-Presidents: Mr. Alfred Giles, M.P., Sir Robert Rawlinson, Sir Benjamin Baker, F.R.S., and Sir James N. Douglass, F.R.S. Members of Council: Dr. W. Anderson, F.R.S., Messrs. J. Wolfe Barry, Alex. R. Binnie, E. A. Cowper, Sir Douglas Fox, Messrs. J. C. Hawkshaw, Charles Hawksley, Sir Bradford Leslie, Messrs. George Fosbery Lyster, James Mansergh, Sir Guildford L. Molesworth, Mr. W. H. Preece, F.R.S., Sir E. J. Reed, F.R.S., M.P., Messrs. William Shelford and Francis W. Webb.

The Scientific Spirit—Old and New.—The following appeared in *Industries* of June 3rd, the writer veiling his identity under the initials "W. M. M.":—

"About 200 years ago a young man, whose name is still held of some account, was engaged in the work of verifying by calculation a theory of his own respecting the curve of the moon's motion in its orbit. There was a discrepancy of 14 or 15 per cent. between the observed and calculated results, and consequently he laid aside at that time any further consideration of the matter. On Friday last the members of the Physical Society assembled in force to hear another young man, whose name is now held of some account, give a statement of the evidence for and against the theory that the earth carries the ether with it in its motion round the sun. The lecture was illustrated with many diagrams of experiments, mostly negative or inconclusive in their results. *Inter alia* there was a diagram of observed and calculated results, showing a discrepancy of about 99 per cent. But science has advanced since Newton's time, and the last thing any modern scientific man would think of doing is to 'lay aside all further thought of this matter' on account of a trifling discrepancy of this sort. There is a good deal to be said for this modern view. Newton was right after all, and a too scrupulous delicacy might have caused him to miss his greatest discovery and the *kudos* attached to it. Adams first calculated the position of Neptune, but Le Verrier published first; and your modern man does not mean to be caught napping so, even if he has to publish before finishing his calculation. Does not Mayer share with Joule in the opinion of half the world the credit of the theory of the conservation of energy, and who would have heard of him if he had stopped to verify? We are even told that it is little short of a crime to 'hide the light that is in us,' no matter how feeble and flickering it may be, lest haply some one greater should waste his strength collecting and arranging the uncompleted work, as Maxwell did for Cavendish. And yet—and yet—the *Principia* will endure for all time: will 'Modern Views of Electricity,' with its choice of inconsistent hypotheses, or 'Electro-magnetic Theory,' with its *rational* (!) system of units, its uncouth phraseology, and its petulant contempt for whatever is not brand new, stand such a test? A bigot for classical education, with an insufficient appreciation of Newton's genius, attributes his superiority in part to the fact that he published in Latin. 'You may think any scientific nonsense you please,' says this misguided person, 'and you may write it down readily enough in English; but you can't put it into Latin, nor, easily, into French. If it goes readily into German, it is probably more scientific and worse nonsense than usual.' But that, of course, is absurd. In these days it is often almost as good a deed to kill a false hypothesis as to establish a true one; and for this purpose the publication of negative results is most useful, nor is it contrary to precedent. Kepler gave his failures to the world, but only after he had arrived at the truth; Faraday gives his negative results, but he draws the logical inference from them. In each case we could ill spare the insight obtained into the mind and method of a genius. A reasonable rule might be laid down that only those who succeed are entitled to show where they have failed; but then how meagre would be the reports of our scientific societies!"

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ELECTROMAGNETIC THEORY.—XXX.

BY OLIVER HEAVISIDE.

(*Continued from page 87.*)

§ 141. These properties of the space-integrals of scalar products in the divergent series are formally obtainable from the corresponding ones in the circuital series by changing the suffix from 1 to 2; at the same time changing the type from clarendon to roman should the quantity typified be a scalar. Thus, analogous to (262), (263), we have

$$\Sigma \mathbf{C}_2^2 = \Sigma \mathrm{B}_2\mathrm{D}_2 = \Sigma \mathbf{A}_2\mathbf{E}_2 = \ldots \quad . \; . \quad (265)$$

$$\Sigma \mathrm{D}_2^2 = \Sigma \mathbf{C}_2\mathbf{E}_2 = \Sigma \mathrm{B}_2\mathrm{F}_2 = \ldots, \quad . \; . \quad (266)$$

starting from the square of a vector in the first set, and from the square of a scalar in the second. These transformations all rest upon (249); that is, we pass from any form to the next by the exchange of $-\nabla$ and div between the factors. For example,

$$\begin{aligned} \Sigma \mathrm{D}_2^2 &= \Sigma \mathrm{D}_2 \operatorname{div} \mathbf{C}_2, && \text{by definition of } \mathrm{D}_2, \\ &= -\Sigma \mathbf{C}_2 \nabla \mathrm{D}_2, && \text{by integration, using (249),} \\ &= \Sigma \mathbf{C}_2\mathbf{E}_2, && \text{by definition of } \mathbf{E}_2. \end{aligned}$$

Similarly in all the rest. The preceding equations conveniently summarise them.

But it will be observed that there is another way of pairing terms in the divergent series, viz., a vector with a scalar. The corresponding transformations do not work so symmetrically as the previous. For instance,

$$\begin{aligned} \Sigma \mathbf{C}_2\mathrm{D}_2 &= -\Sigma \nabla \mathrm{B}_2.\mathrm{D}_2, && \text{by definition of } \mathbf{C}_2, \\ &= \Sigma \mathrm{B}_2 \nabla \mathrm{D}_2, && \text{by (244),} \\ &= -\Sigma \mathrm{B}_2\mathbf{E}_2, && \text{by definition of } \mathbf{E}_2, \\ &= -\Sigma \operatorname{div}\mathbf{A}_2.\mathbf{E}_2, && \text{by definition of } \mathrm{B}_2, \\ &= \Sigma \mathbf{A}_2 \nabla.\mathbf{E}_2, && \text{by integration.} \quad . \quad (267) \end{aligned}$$

Here the symmetry breaks down. The last transformation depends upon

$$\Sigma (\mathbf{N}\mathfrak{f})\mathfrak{g} = \Sigma (\nabla\mathfrak{f})\mathfrak{g} = \Sigma (\mathfrak{g} \operatorname{div} \mathfrak{f} + \mathfrak{f}_\nabla.\mathfrak{g}), \quad . \; . \quad (268)$$

which is a case of the theorem (147) or (153). Note that in the second form ∇ has to differentiate both $\mathfrak{f}$ and $\mathfrak{g}$, so that the full expression is in the third form. If the surface-integral vanishes at infinity, we have

$$\Sigma \mathfrak{g} \operatorname{div} \mathfrak{f} = -\Sigma \mathfrak{f}\nabla.\mathfrak{g}, \quad . \; . \; . \; . \quad (269)$$

which is the transformation used in getting (267). We have also, by going the other way,

$$\Sigma \mathbf{C}_2\mathrm{D} = \Sigma \mathbf{C}_2 \operatorname{div} \mathbf{C}_2 = -\Sigma \mathbf{C}_2\nabla.\mathbf{C}_2, \quad . \; . \quad (270)$$

by using the same transformation (269). Next take $\mathrm{D}_2\mathbf{E}_2$. Here the vector is the slope of the scalar it is multiplied by, whereas in the former case, the divergence of the vector was the associated scalar. So it now goes quite differently. Thus,

$$\Sigma \mathrm{D}_2\mathbf{E}_2 = -\Sigma \mathrm{D}_2\nabla\mathrm{D}_2 = -\Sigma \nabla\tfrac{1}{2}\mathrm{D}_2^2 = -\Sigma \mathbf{N}\tfrac{1}{2}\mathrm{D}_2^2 \quad . (271)$$

The result is therefore zero, if the surface-integral at infinity vanishes.

§ 142. It usually happens that potentials present themselves in physical mathematics as auxiliary functions introduced to facilitate calculations relating to other quantities. But in the theory of the elastic solid, the potential function presents itself in a very direct and neat manner; besides that, the elastic theory presents excellent illustrations of the above transformations and the general theory of ∇. If the solid be homogeneous and isotropic, there are but two elastic constants, the rigidity n and the coefficient of resistance k to compression or expansion. Let also $m = k + \frac{1}{3}n$, in Thomson and Tait's notation; then the equation of motion is

$$\mathfrak{f} + n\nabla^2\mathfrak{G} + m\nabla \operatorname{div} \mathfrak{G} = \rho\ddot{\mathfrak{G}}, \quad . \; . \; . \quad (272)$$

where $\mathfrak{G}$ is the displacement, and $\mathfrak{f}$ the impressed force per unit volume, whilst ρ is the density. Whatever limitations may need to be put upon the values of m and n in treating of solids as we find them, in speculations relating to ethers they may have any values not making the stored energy negative. Thus m may, as we shall see presently, go down to the negative value $-n$, keeping n positive.

Split $\mathfrak{f}$ into $\mathfrak{f}_1 + \mathfrak{f}_2$, and $\mathfrak{G}$ into $\mathfrak{G}_1 + \mathfrak{G}_2$, where $\mathfrak{f}_1$ and $\mathfrak{G}_1$ are circuital, and the others divergent. Then (272) may be split into two equations, one circuital, the other divergent. Thus, remembering (193),

$$\mathfrak{f}_1 + n\nabla^2\mathfrak{G}_1 = \rho\ddot{\mathfrak{G}}_1, \quad . \; . \; . \; . \; . \; . \; . \; . \quad (273)$$

$$\mathfrak{f}_2 + (n+m)\nabla^2\mathfrak{G}_2 = \rho\ddot{\mathfrak{G}}_2. \quad . \; . \; . \; . \; . \; . \; . \; . \quad (274)$$

In the circuital equation k does not appear, so that the propagation of circuital disturbances depends only upon the rigidity and density; speed, $(n/\rho)^{\frac{1}{2}}$. In the divergent equation both n and k appear, and the speed of disturbances of this class is $\{(n+m)/\rho\}^{\frac{1}{2}}$. In another form, if we take the curl of (272), the divergence goes out, so that the curl of $\mathfrak{G}$, which is twice the rotation, has the curl of $\mathfrak{f}$ for source, and is propagated independently of compressibility.

And if we take the divergence of (272), we see that the divergence of $\mathfrak{G}$, or the expansion, has the divergence of $\mathfrak{f}$ for source, and the rate of its propagation depends upon both rigidity and compressibility. But when $m = 0$, there is but one speed of propagation, and a complete amalgamation of the two kinds of disturbances.

In equilibrium, when equilibrium is possible, the right members of the last three equations vanish, since they represent "rate of acceleration of momentum" (a long-winded expression). We therefore have

$$\mathfrak{f}_1 = -n\nabla^2\mathfrak{G}_1, \quad . \; . \; . \; . \; . \; . \quad (275)$$

$$\mathfrak{f}_2 = -(n+m)\nabla^2\mathfrak{G}_2. \quad . \; . \; . \quad (276)$$

The solutions are visible by inspection. We see that $n\mathfrak{G}_1$ is the potential of $\mathfrak{f}_1$, and $(n+m)\mathfrak{G}_2$ the potential of $\mathfrak{f}_2$. That is, the displacement produced by circuital impressed force is its potential divided by n; and the displacement produced by divergent impressed force is its potential divided by $n+m$; whilst, in the general case, we must split the impressed force into circuital and divergent parts, and then re-unite them in different proportions to obtain the resultant displacement. Symbolically,

$$n\mathfrak{G}_1 = \operatorname{pot} \mathfrak{f}_1, \quad . \; . \; . \; . \; . \quad (277)$$

$$(m+n)\mathfrak{G}_2 = \operatorname{pot} \mathfrak{f}_2, \quad . \; . \; . \; . \; . \quad (278)$$

$$\mathfrak{G} = \frac{\operatorname{pot} \mathfrak{f}_1}{n} + \frac{\operatorname{pot} \mathfrak{f}_2}{m+n}. \quad . \; . \; . \; . \; . \quad (279)$$

In the case of incompressibility k, and therefore m, is infinite, so that $\mathfrak{G}_2$ is zero, and the displacement is $\operatorname{pot} \mathfrak{f}_1/n$, whatever $\mathfrak{f}_2$ may be. For $\mathfrak{f}_2$ is balanced by difference of pressure, which is set up instantly. The corresponding speed is infinite, but there is no displacement.

If, again, $m = 0$, and there is but one speed, the displacement is the potential (divided by n) of the impressed force, whatever be its type.

On the other hand, if $n + m = 0$, we see by (274) that there is no steady state possible due to divergent force, as $\mathfrak{f}_2$ is then employed simply in accelerating momentum on the spot. The corresponding speed is zero. The circuital disturbances are propagated as before. This is the case of Sir W. Thomson's contractile ether, in which the wave of normal disturbance is abolished by making the speed zero.

§ 143. We may also find expressions for the stored energy from the equation of motion. The work done and stored by the impressed force $\mathfrak{f}$ is $\frac{1}{2}\mathfrak{f}\mathfrak{G}$, though, if $\mathfrak{f}$ be put on suddenly, an equal amount is dissipated, since, $\mathfrak{G}$ being the final displacement, $\mathfrak{f}\mathfrak{G}$ is the work then done by $\mathfrak{f}$, per unit volume. Now

$$\Sigma \tfrac{1}{2}\mathfrak{f}\mathfrak{G} = \Sigma \tfrac{1}{2}\mathfrak{f}_1\mathfrak{G}_1 + \Sigma \tfrac{1}{2}\mathfrak{f}_2\mathfrak{G}_2,$$

by (264). Calling the first part U_1, and the second part U_2, we have, by (273), (274),

$$\mathrm{U}_1 = -\Sigma \tfrac{1}{2}n\mathfrak{G}_1\nabla^2\mathfrak{G}_1 = \Sigma \tfrac{1}{2}n(\operatorname{curl} \mathfrak{G})^2 \quad . \; . \; . \; . \quad (280)$$

$$\mathrm{U}_2 = -\Sigma \tfrac{1}{2}(m+n)\mathfrak{G}_2\nabla^2\mathfrak{G}_2 = \Sigma \tfrac{1}{2}(m+n)(\operatorname{div} \mathfrak{G})^2. \quad (281)$$

The transformations here used are (259) for U_1 and (249) for U_2. We see that the energy stored is expressed in terms of the squares of the rotation and of the expansion. In the contractile ether U_2 is zero, and the stored energy is U_1. We do not correctly localise the energy by the above formulæ, but only express the total amounts. For correct localisation

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we need to know the stress and the distortion. Now the distortion is a function of the variation of displacement, so is known in terms of $\mathbf{G}$. Can we, however, find the stress itself from the equation of motion? If not, we can come very close to it. Thus, in a state of equilibrium, $\mathbf{F}+\mathbf{f}=0$, if $\mathbf{F}$ is the force arising from the stress. So, by (275), (276),

$$\mathbf{F}_1 = n\nabla^2\mathbf{G}_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (282)$$

$$\mathbf{F}_2 = (n+m)\nabla^2\mathbf{G}_2, \quad . \quad . \quad . \quad . \quad . \quad (283)$$

and

$$\mathbf{F} = n\nabla^2\mathbf{G} + m\nabla^2\mathbf{G}_2. \quad . \quad . \quad . \quad . \quad (284)$$

Now let $\mathbf{P}_N$ be the stress on the plane whose normal is $\mathbf{N}$. We have, by consideration of the equilibrium of a unit cube,

$$\mathbf{FN} = \operatorname{div}\mathbf{P}_N, \quad . \quad . \quad . \quad . \quad . \quad . \quad (285)$$

to express the relation between an irrotational stress and the force arising from it. Therefore, applying this to (284),

$$\operatorname{div}\mathbf{P}_N = n\nabla^2\mathbf{GN} + m\nabla^2\mathbf{G}_2\mathbf{N}. \quad . \quad . \quad . \quad (286)$$

Here the divergence of $\mathbf{P}_N$ is given; find $\mathbf{P}_N$ itself. The immediate answer is, by (201), or (214),

$$\mathbf{P}_N = -\nabla\operatorname{pot}\operatorname{div}\mathbf{P}_N,$$

or

$$\mathbf{P}_N = n\nabla\mathbf{GN} + m\nabla\mathbf{G}_2\mathbf{N}, \quad . \quad . \quad . \quad (287)$$

provided $\mathbf{P}_N$ is divergent. That is, we have constructed a stress-vector giving the proper force required. But, without interfering with this essential property, we might add on to the right side of (287) any circuital vector. That we must do so now, we may see by remembering that the stress must be irrotational, or produce no torque, and then by finding that (287) does give a torque. To show this, consider the first part only of the stress (287), say with $m=0$. Then

$$\mathbf{NP}_M - \mathbf{MP}_N = n(\mathbf{N}\nabla.\mathbf{MG} - \mathbf{M}\nabla.\mathbf{NG}).$$

Here take $\mathbf{M}=\mathbf{j}$ and $\mathbf{N}=\mathbf{k}$; then

$$\mathbf{kP}_j - \mathbf{jP}_k = n(\nabla_3 G_2 - \nabla_2 G_3) = -n\operatorname{i}\operatorname{curl}\mathbf{G},$$

by (149). This gives the $\mathbf{i}$ component of the torque, which is therefore $-n\operatorname{curl}\mathbf{G}$. But $\mathbf{G}_2$ has no curl, therefore the second part of (287) produces no torque. We require, therefore, to add to $\mathbf{P}_N$ in (287) a stress giving no force, but a torque $n\operatorname{curl}\mathbf{G}$. Such a stress is

$$\mathbf{X}_N = n\operatorname{curl}\mathrm{V}\mathbf{GN} \quad . \quad . \quad . \quad . \quad . \quad (288)$$

as may be tested in the above manner.

This brings us from (287) to

$$\mathbf{P}_N = n(\nabla\mathbf{GN} + \operatorname{curl}\mathrm{V}\mathbf{GN}) + m\nabla\mathbf{G}_2\mathbf{N}, \quad . \quad . \quad (289)$$

which is a stress-vector giving the correct force and no torque. But on comparison with the real stress deduced from the elastic properties of a solid, which is

$$\mathbf{P}_N = n(\nabla.\mathbf{GN} + \mathbf{N}\nabla.\mathbf{G}) + \mathbf{N}(m-n)\operatorname{div}\mathbf{G} \quad . \quad . \quad (290)$$

we see that they do not agree. Yet they can only differ by a stress which produces neither force nor torque. And we know already, by (288), that if $\mathbf{G}=\mathbf{G}_2$, the modified stress will give no force or torque. In fact, on comparing (289), (290), we find that their difference is of this nature, (290) being equivalent to

$$\mathbf{P}_N = n(\nabla\mathbf{GN} + \operatorname{curl}\mathrm{V}\mathbf{GN}) + m(\nabla\mathbf{G}_2\mathbf{N} - \operatorname{curl}\mathrm{V}\mathbf{G}_2\mathbf{N}), \quad (291)$$

where the first and third terms on the right are sufficient to give the correct force, but with a torque, which is, however, cancelled by the second term; whilst the fourth term is apparently (so far as force and torque are concerned) like a fifth wheel to the coach, off the ground. If we inquire under what circumstances the real stress can assume this singular form, we shall find that $m+n=0$ and $\operatorname{curl}\mathbf{G}=0$ will do it. With these conditions, only the circuital part of $\mathbf{P}_N$ is now left, and (291) reduces to

$$\mathbf{P}_N = 2n\operatorname{curl}\mathrm{V}\mathbf{G}_2\mathbf{N}. \quad . \quad . \quad . \quad . \quad (292)$$

It is the case of irrotational displacement in the contractile ether, previously referred to, and is entirely remote from the real elastic solid. The noteworthy thing is that we cannot apparently conclude what the stress is, even when the force and torque to correspond are everywhere given, owing to the forceless and torqueless stress coming into the formulæ. The form (292) is convenient for showing at sight that there is no force. It may, by (181), remembering the constancy of $\mathbf{N}$, be expanded to

$$\mathbf{P}_N = 2n(\mathbf{N}\nabla.\mathbf{G}_2 - \mathbf{N}\operatorname{div}\mathbf{G}_2), \quad . \quad . \quad . \quad (293)$$

where put $\mathbf{N}=\mathbf{i}, \mathbf{j}, \mathbf{k}$ in turns to get the three stresses on the planes having these normals. One-third of the sum of the normal tractions on these planes is $-(4n/3)\operatorname{div}\mathbf{G}_2$, or, which is the same, $+k\operatorname{div}\mathbf{G}$. It is the negative of the pressure. But in the real stress (291) itself, the fourth part, from its having the negative sign prefixed, correctly associates pressure and compression. But this forceless and torqueless stress does not contribute anything to the total energy. The amount of stored energy is

$$\begin{aligned}\Sigma\tfrac{1}{2}\mathbf{fG} &= -\Sigma\tfrac{1}{2}\mathbf{FG} = -\tfrac{1}{2}\Sigma(\mathbf{F}_1\mathbf{G}_1 + \mathbf{F}_2\mathbf{G}_2 + \mathbf{F}_3\mathbf{G}_3)\\ &= -\tfrac{1}{2}\Sigma(\mathbf{G}_1\operatorname{div}\mathbf{P}_1 + \mathbf{G}_2\operatorname{div}\mathbf{P}_2 + \mathbf{G}_3\operatorname{div}\mathbf{P}_3)\\ &= \tfrac{1}{2}\Sigma(\mathbf{P}_1\nabla\mathbf{G}_1 + \mathbf{P}_2\nabla\mathbf{G}_2 + \mathbf{P}_3\nabla\mathbf{G}_3), \quad . \quad . \quad . \quad . \quad (294)\end{aligned}$$

where the first line needs no remark, the second is got by (285), and the third by the common transformation (249), $\mathbf{P}_1$, etc., being the stresses on the $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ planes. The final form in (294) shows the correct distribution of the energy in terms of the stress and the distortion. Now, if in the stress $\mathbf{P}_N$ be included any terms giving rise to no force, the above transformation shows that they contribute nothing on the whole to the energy of distortion. This is the case with the fourth term in (293), and would also be the case with the second term, only that we have no right to ignore it, on account of the torque thereby brought in. If the solid be not unbounded, it is sufficient for its boundary to be at rest for the same principles to apply.

§144. The simple solution (279) may, of course, receive many other forms. If it be desired to find the displacement due to an explicitly given impressed forcive, it is a matter of some importance to select a method of obtaining it which shall not be unnecessarily difficult in execution; for different processes leading to the same result may vary greatly in readiness of application. Now, if the impressed forcive be either circuital or divergent, we do not need to modify. But if of a mixed type, then it may be desirable. Put $\mathbf{f}_1 = \mathbf{f} - \mathbf{f}_2$, then an alternative form is

$$\mathbf{G} = \operatorname{pot}\left(\frac{\mathbf{f}}{n} - \frac{m\mathbf{f}_2}{n(m+n)}\right); \quad . \quad . \quad . \quad (295)$$

and now, when $\mathbf{f}$ is given, it is only the part $\operatorname{pot}\mathbf{f}_2$ that needs development. We have

$$\mathbf{f}_2 = \Sigma\mathbf{r}_1\operatorname{div}\mathbf{f}/4\pi r^2 = \Sigma\nabla p\,.\operatorname{div}\mathbf{f}, \quad . \quad (296)$$

as before explained. Now, if we notice that

$$\nabla^2 r = 2/r, \quad . \quad . \quad . \quad . \quad . \quad (297)$$

which may be proved by differentiating, we can further conclude that

$$\operatorname{pot}(\mathbf{r}_1/4\pi r^2) = \mathbf{r}_1/8\pi, \quad . \quad . \quad (298)$$

a very curious result. The potential of a radial vector following the inverse-square law of intensity is a radial vector with a constant tensor in all space. Using this result, we have

$$\operatorname{pot}\mathbf{f}_2 = \Sigma\mathbf{r}_1\operatorname{div}\mathbf{f}/8\pi, \quad . \quad . \quad . \quad (299)$$

so that (295) becomes

$$\mathbf{G} = \frac{1}{n}\operatorname{pot}\mathbf{f} - \frac{m}{n(m+n)}\Sigma\frac{\mathbf{r}_1\operatorname{div}\mathbf{f}}{8\pi}, \quad . \quad (300)$$

wherein $\mathbf{f}$ alone appears on the right side.

Another form is got by using

$$\mathbf{f}_2 = \nabla\Sigma\mathbf{f}\nabla p, \qquad \therefore \operatorname{pot}\mathbf{f}_2 = \nabla\operatorname{pot}\Sigma\mathbf{f}\nabla p. \quad (301)$$

But a better one is

$$\operatorname{pot}\mathbf{f}_2 = -\Sigma f\nabla\frac{dr}{ds}8\pi, \quad . \quad . \quad . \quad . \quad (302)$$

where s is length measured along $\mathbf{f}$, and f is the tensor of the latter. This makes

$$\mathbf{G} = \frac{1}{n}\operatorname{pot}\mathbf{f} + \frac{m/8\pi}{n(m+n)}\Sigma f\nabla\frac{dr}{ds}, \quad . \quad . \quad (303)$$

which is generally suitable for practical calculation.

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A considerably more complex form is given in Thomson and Tait. It may be obtained from (303) by means of the identity

$$\nabla \frac{dr}{ds} = \frac{2}{3r}\mathbf{s}_1 - \frac{r^2}{3}\nabla \frac{d}{ds}\frac{1}{r}, \quad \ldots \quad (304)$$

where $\mathbf{s}_1$ is unit $\mathbf{s}$, and therefore parallel to $\mathbf{f}$, making

$$\mathbf{G} = \text{pot } \mathbf{f}\left(\frac{1}{n} - \frac{m}{3n(m+n)}\right) + \frac{m}{24\pi n(m+n)} \Sigma f r^2 \nabla \frac{d}{ds}\frac{1}{r}, \quad (305)$$

the same as Thomson and Tait's formulæ when expanded in cartesians. But this is a gratuitous complication, as (301) is simpler in expression and in application. Of course (300) is simpler still in expression, and the practical choice may lie between it and (303), or (295).

Notice that an impressed forcive of the divergent type with a single point-source produces not merely uniform radial displacement, as per (298), but an infinite discontinuity, in fact, a disruption, at the source itself. It is a very extreme case, of course.

(To be continued.)

NOTES ON NOMENCLATURE.

By way of preparation for the International Electrical Congress which it is proposed to hold at Chicago in September, 1893, M. Hospitalier delivers himself in a recent number of *L'Industrie Electrique* of a few observations on his favourite theme of logical electrical nomenclature. M. Hospitalier, as it has been remarked, is "the soul of method" in this matter; and we cannot, therefore, do better than give our readers the benefit of his opinions in full:—

My first observation relates to the too marked national individualism exhibited by the representatives of the different nations brought together with a view of coming to international decisions, and the repugnance which they show to enforce these decisions in every-day work when they do not happen to give entire satisfaction to national *amour propre*.

Up to 1881 the practical unit of resistance was the B.A. ohm, represented by the resistance of a column of mercury 104·8cm. long and 1 sq. mm. cross-section at the temperature of melting ice. As a result of the Congress of 1881, the International Conference appointed to consider the length of the column of mercury representing the ohm, defined as equal to 10^9 C.-G.-S. units, more accurately decided that the length should be 106cm., and gave it the name of *legal ohm*. But the legal ohm has never been accepted in England, and for some years the English have adopted, under the title of *true ohm*, the resistance of a column of mercury of 106·3cm.

Let me remark that the term *true ohm* is a deplorable one, and absolutely incorrect, since the true ohm is by definition equal to 10^9 C.-G.-S. units, and has for us only an asymptotic value. We shall approximate the true value more and more by determinations more and more accurate, but we shall never actually reach it. The first mission of the Chicago Congress will, therefore, be to evolve some degree of order out of this chaos of B.A., *legal*, *true*, and other ohms.

The 1889 Congress gave the name of *quadrant* to the unit of self-induction, and defined it as follows:—One *quadrant* = 10^9 C.-G.-S. units of self-induction. This name formed an exception to the rule adopted in 1881 with regard to the nomenclature of units. It was everywhere badly received, and it is nearly certain that the Chicago Congress will sanction the name of *henry* in place of the term *quadrant*, which designates more particularly a length equal to 10^9cm.

The 1889 Congress adopted the terms *watt* and *joule* respectively for the volt-ampere and the volt-coulomb; but it is only since the Frankfort Congress of 1891 that the Germans have partially given up the volt-ampere and volt-coulomb.

My second remark relates to the useless creation of new names. I consider that the *rôle* of a Congress is to fix for all time the name of a new physical quantity or of a new unit each time that it is necessary to do so, but not to indefinitely multiply these names to the annoyance of those who have to use them. The Board of Trade has afforded us a case in point. When the question arose of selling electrical energy supplied from central stations, and of devising an appropriate unit, the Board of Trade decided to take as its unit the energy corresponding to a current of 1 ampere at a difference of potential of 1,000 volts, lasting one hour,* and it unfortunately baptised it in the senseless name of *unit*—a name short indeed, but one which in practice has become, in order to avoid confusing it with other units of energy, the *Board of Trade unit*. Recently, this name appearing cumbersome, it was proposed to call this unit the *kelvin*, a proposition which was immediately withdrawn at the request of the godfather, Lord Kelvin (Sir William Thomson), who suggested the term *supply unit*. I may, perhaps, be allowed to remark that all these names are utterly useless. Since the units watt and hour have an official and legal character, and since the prefix *kilo* has been adopted by all nations as indicating multiplication by 1,000, it is both simple and logical to call the energy corresponding to 1,000 watts during an hour the *kilowatt-hour*. If people prefer to adopt in practice a unit ten times smaller, as is generally done in France, this unit of energy will be called the *hectowatt-hour*; and all the world will understand what is meant without any further explanation, and without burdening the memory.

As a general rule, physical quantities and their units should be formed by successive definitions, and should not bear special names unless the compound word is too long or too difficult to pronounce, which is not the case in regard to the kilowatt-hour.

[* The following is the actual definition:—The expression "unit" shall mean the energy contained in a current of 1,000 amperes flowing under an electromotive force of 1 volt during one hour.—ED. *E.*]

BOOKS, &c., RECEIVED.

"Dynamo-Electric Machinery. A Manual for Students of Electrotechnics." By Silvanus P. Thompson, D.Sc., B.A., F.R.S. Fourth Edition. Enlarged and revised. (London: E. and F. N. Spon.)

"Telephone Company of Ireland's First List of Subscribers." April, 1892.

"The Construction of Gas Works practically described." By W. R. Herring. (London: Hazell, Watson and Viney.)

"Professional Papers of the Corps of Royal Engineers." Edited by Captain W. A. Gale, R.E., Royal Engineers Institute. Occasional Papers, Vol. XVII., 1891. (Chatham: Royal Engineers Institute.)

"Journal of the Institution of Electrical Engineers." Vol. XXI. No. 98. (London and New York: E. and F. N. Spon.) Price 3s.

"American Journal of Science." Vol. XLIII. No. 257. (New Haven, Conn.: J. D. and E. S. Dana.)

"Transactions of the American Institute of Electrical Engineers." Vol. IX. No. 3. (New York: The Institute.)

"Elektrotechnischer Unterricht und Anleitung zum Betriebe elektrischer Anlagen insbesondere auf Kriegschiffen," by M. Burstyn. (Vienna: Carl Gerold, jun.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, June 10th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1.) "Some Points connected with the Electromotive Force of Secondary Batteries.' By Dr. J. H. Gladstone and W. Hibbert. (2.) "Workshop Ballistic and other Shielded Galvanometers." By Prof W. E. Ayrton and T. Mather.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Magnetic Properties of Liquid Oxygen." By Prof. Dewar, F.R.S.

MONDAY, June 13th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7.30 p.m. Ordinary Meeting. Paper to be read: "Foreign Sewage Precipitation Works," by Albert Wollheim.

WEDNESDAY, June 15th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting. Papers to be read: (1.) "English Climatology, 1881-1890." By F. C. Bayard, LL.M. (2.) "The Mean Temperature of the Air on each Day of the Year at the Royal Observatory, Greenwich, on the average of the Fifty Years 1841 to 1890." By William Ellis, F.R.A.S.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Ordinary General Meeting.

THURSDAY, June 16th.

CHEMICAL SOCIETY.

8 p.m. Ordinary Meeting. Ballot for the election of Fellows. Papers to be read: (1.) "Contributions to an International System of Nomenclature. The Nomenclature of Cycloids." By Dr. H. E. Armstrong. (2.) "The Production of Pyridine Derivatives from the Lactone of Triacetic Acid." By Dr. N. Collie,

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MISPLACED INVENTIONS.

The development of the electrical industry in opening fresh fields for the play of invention has been accompanied by a waste of ingenuity such as the history of arts and manufactures has probably never before witnessed, so easy is it to scheme ways of doing this or that by electricity. The devising and experimenting are fascinating to some minds; and too often the practical value of the idea is lost sight of, and the satisfactory working of a model is confounded with a commercial success. While the numberless arc-lamp movements which have been invented during the past twelve or fourteen years are a remarkable example of such squandered ingenuity, the waste of time is not so serious as in other matters, for the large majority of the inventors have been ignorant of the conditions of the problem; they merely fumbled with magnets and bungled with escapements, and were good for little else. The result of their labours is a hundred or two of nearly hopeless failures, a score of passable lamps and three or four excellent ones. The attempts were excusable, for a good arc lamp was wanted.

Another favourite problem is the station indicator for trains. There are three propositions concerning the station indicator: firstly, there are few, if any, in daily use; secondly, some passengers would appreciate them; and thirdly, "it can be done by electricity." That is quite sufficient for the unhappy inventor; and he sets to work with bands on rollers,

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fingers on dials, or even pointers on maps, and makes a model that will work. But the railway companies fail to see in what way the adoption of the system will add a shilling to their revenue, even if the apparatus were presented to them and fitted free of cost; while it would be liable to get out of order and deceive their passengers. If the station indicator could be combined with "a penny-in-the-slot" there might be some inducement for the railway companies to take it up; but "a twopence-in-the-slot" speaking-tube, communicating with the guard, would be better, one of the pennies, of course, going to the guard; but there would be no excitement in inventing that, neither ingenious mechanisms nor electricity would be wanted. Sending pictures and writing by telegraph has attracted a few dozen inventors; it can be done whenever there is a demand. Telegraphic or telephonic communication between railway passenger, guard, engine-driver and signalmen, has been devised over and over again; and because it has never been seriously put in practice there are always inventors who think that it has never been proposed. Probably, not one in twenty of these patentees have ever travelled on an engine, or have any idea even of the kind of electric bell which would be suitable for fixing in such a situation. We have ourselves intercepted a semaphore message of a strictly domestic character relating to a frying-pan, sent by a coastguard while on duty; but the work of a coastguard differs considerably from that of an engine driver. It would, no doubt, be a great scientific triumph, which would be duly paragraphed into fame by the daily papers, if the driver of an express could ask to be "put through" to the general manager and tell him that as he had learned from the signalmen that the line was clear ahead for about 70 miles, he would like to take the opportunity of expressing his views on the eight-hours question. We should be sorry, however, to travel behind that driver if the signalling were dependent on sliding contacts and insulated mid-rails.

Many of the inventors to which we have alluded are either amateurs or have gone to work in an amateur fashion. Such men have a literature of their own, and societies of their own; some few have an incurable mania for invention, associated too often with a carelessness of expression which is liable to be confounded with deliberate falsehood. There are, however, plenty of examples of misapplied work among professional men, and in these the error is often in the application rather than the thing itself. A man makes motors, and he wants to find a new market for them; he fits one up in combination with a winch or capstan of a ship, without perhaps the smallest knowledge of the way in which winches are handled when at work, or the usages to which they are subjected at other times. Another man, in happy ignorance of the practical details of railway working, sets himself down to design, say, an electric locomotive which shall "whip creation," with the result that it beats the record, though scarcely in the manner expected by the sanguine inventor. But instances of misplaced ingenuity are as the sands of the sea-shore.

Invention is an art, in so far that it is an exercise of originality, and that it is sometimes of the nature of an inspiration; for this reason, together, perhaps, with the fact that it is occasionally rewarded by substantial profits, an unwarrantable importance has been attached to it. But invention unaccompanied by research and discovery does not call for any high order of intellect, and often has a mischievous effect on temperament and character. The statistics of invention as a business are impossible to arrive at, but it is not improbable that if dissociated from the commercial genius which is generally contributed, not without due reward, by someone else, more money is lost than is made by miscellaneous inventing. On the whole, therefore, the best advice to give to those about to invent is "Don't." We are afraid, however, that there is as little likelihood of this cautious counsel being taken to heart by inventors as there is of its being listened to by those to whom it was originally addressed. Three golden rules may, perhaps, be laid down: first, make sure your panacea is wanted, and that the game is worth the candle; then make sure that no one else has thought of it before; lastly, make yourself thoroughly acquainted with the practical working conditions of the problem to be solved. Then, and not before, it will be time enough to sit down and circumvent prior patents and the difficulties of the case.

REVIEWS.

A Treatise on Electricity and Magnetism. By JAMES CLERK MAXWELL. Third edition, 1892. (Oxford: Clarendon Press.)

This work consists of a carefully revised reprint of the second edition, published ten years ago under the direction of Mr. W. D. Niven. The pressure of other duties has rendered it impossible for Mr. Niven to see the present edition through the press, and Prof. J. J. Thomson has accordingly undertaken the task. It was the original intention of the editor to supply in the form of foot-notes some account of the great advances made in the science of electricity since the publication of the first edition of this work 20 years ago. The unparalleled extent of the changes during this period, due in no small degree to the views introduced by Maxwell's great work, are, however, such that Prof. Thomson's idea could only have been carried out by considerably increasing the bulk of the book. Rather than do this it has been thought preferable to issue a "supplementary volume," the publication of which is promised shortly. Probably far more will be expected of this new work than any single volume can supply; but, in the meanwhile, the foot-notes and additions made in the present reprint are neither few nor unimportant. One of the appendices contains a description of Maxwell's method of determining the self-induction of a coil, reprinted from his classical Paper on the Dynamical Theory of the Electro-Magnetic Field. This method, although invented and described in the *Phil. Trans.* for 1865, or nearly thirty years ago, is now for the first time published in an easily accessible form. Another valuable extract from the same Paper appears on page 245, as a note to Chapter VIII., dealing with the investigation of the magnetic field. Mr. Heaviside's assumption that all electric currents flow in closed circuits, which leads to certain great simplifications in the equations representing the magnetic state of the field, is also discussed in a lengthy mathematical note. An appendix, several pages in length, is inserted at the end of Chapter IX., and other appendices occur.

An important mathematical addition on pp. 323-5 deals with the subject of the distribution of the current in conductors subjected to the action of rapidly-changing electromotive forces; but it is hardly fair that the name of Prof. Hughes should be omitted in reference to this matter. Maxwell clearly pointed out in mathematical language the influence of self-induction in causing alternate currents to crowd towards the outer parts of conducting wires. But no one paid any attention to this matter, or had any numerical idea of the extent to which this effect took place, till Prof. Hughes, with marvellous experimental skill, detected the effect, and brought it into public notice in his Presidential Address to the Society of Telegraph Engineers in 1886. The interpretation of the measurements made, owing to the novelty and difficulty of the subject, was somewhat confused at the time, as was indeed evidenced by the lengthy discussion which took place after Prof. Hughes's Paper. One result was, however, to induce Lord Rayleigh to take up the subject mathematically; and he found, what no one seemed to have previously suspected, that this since-called "skin effect" could, under certain circumstances, become of marked importance. If, however, Prof. Hughes had not made his experiments, it is probable that mathematicians, when recalling this effect, would consider it

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altogether negligible, and that all others would be ignorant of its existence.

Prof. Thomson makes several brief references to recent experimental work which has tended to confirm the views of Maxwell, or which illustrates or modifies the statements made in the work. Thus we notice, among others, an allusion to Helmholtz's restriction to Thomson's law for deducing the electromotive force of a cell from the heat-equivalents of the chemical combinations occurring within the cell. The Hall effect is referred to in connection with those passages of Maxwell's work whereon it bears, and Ewing's researches are alluded to in the chapter on Magnetism. In the chapter on the Electro-Magnetic Theory of Light several references naturally occur to recent work, but these are not so numerous as might have been expected. On page 436 a long list of determinations of "v" is inserted. On page 438 reference is made to measurements with electrical oscillations, tending to verify the law connecting the refractive index of a substance with its specific inductive capacity; and on page 441 a lengthy and valuable note is added explaining the nature of the forces exerted by light when incident on a reflecting surface.

Prof. Thomson has not always been able to verify the results which Maxwell gives without proof, and occasionally remarks of a critical nature have been added about the reasoning used in the text. Perhaps the most important of these criticisms is that on page 192, dealing with the deductions of the equations of induction from the principle of the conservation of energy.

While a reissue of Maxwell's great treatise, to be followed soon by a supplementary volume, is very satisfactory in itself, what is, perhaps, more generally required is a brief, clear statement of what Maxwell's theory really consists. The greater part of Maxwell's work deals with matter which is not essential to his theory of light, to which, after all, the chief value of the treatise is due. Poincaré's French Treatise on *Electricité et Optique*, and Hertz's German reprint of his remarkable researches on electrical oscillations, are the most recent outcome of the electro-magnetic theory. It seems very strange that there does not exist in English any connected account, free from the presence of extraneous matter, of what this theory actually is.

Die Akkumulatoren für Elektricität. By EDMUND HOPPE. One vol. Second edition. (Berlin: Julius Springer. 1892.)

This is the most complete work on the subject we have yet seen. Starting with the discoveries of Humboldt and Dr. Ash in 1797, a summary of the principal work done on the subject of electrolysis, and the theories which have been founded on it are given, and the work is brought very well up to date. Then follows a chapter on the secondary reactions produced by the current and "polarisation." References are very freely given all through, and the credit due to the different workers is fairly apportioned on the whole, though English readers will probably be inclined to claim a little more for their own countrymen. The second part of the book deals with the construction of commercial reversible batteries, starting with Planté's, and describing the leading derivatives from this and the Faure cell, and the various other types which have been suggested from time to time. A list of the principal patents is given, with dates of expiry and names of present holders as far as possible, which should be of great value to manufacturers. Following this is a section devoted to the researches which have been made on the chemistry and efficiency of the batteries. This portion of the work is particularly valuable, as the introductory chapters have made clear the grounds on which the various theories put forward are based, so that it is possible to follow the arguments advanced in support or contradiction of them. The next section deals with the tests which have been made on cells by particular makers from time to time, and the work concludes with a section devoted to the varions applications of reversible batteries to electric lighting, traction, telegraphy, &c., and the best disposition of them for each purpose. The book is well and clearly illustrated, numerous tables are given, and altogether a vast amount of information has been got into a small compass.

Secondary Batteries. By J. T. NIBLETT.

We have received from the author a copy of this book, which is, as stated on the title-page, "A Description of the Modern Apparatus for the Storage of Electrical Energy," and is mainly a reprint.

All the leading cells of the lead, lead-zinc, alkaline, and other types are described, and many which have heretofore remained buried in the obscurity of the Patent Office; but as the descriptions are not full enough, in most cases, to enable a would be patentee to discover whether his idea has been anticipated or not, it strikes one that the value of the book would be much enhanced to the practical man if the date and number of the patent referred to, as well as the name of the inventor, were given in a future edition. Concerning the chemistry of the cell very little is said, but the value in reducing sulphating of the addition of soda to the electrolyte, as suggested by Mr. Barber Starkey, is pointed out. In the appendix will be found some information regarding the chemical properties of the materials used in the construction of secondary batteries.

A Manual of Physics, being an Introduction to the Study of Physical Science, designed for the use of University Students. By W. PEDDIE, D.Sc., F.R.S.E. (London: Baillière, Tindall and Cox).

This text-book, of which we give the full title and description appearing on the title page, is intended to review the principles of the subject in one small volume, and yet it cannot be said to be in any sense an elementary work, but is addressed to readers who already enjoy a very fair knowledge of not only pure, but of applied, mathematics and quaternions. The book would be very useful to students who have deferred their study of physics until they have made considerable advance in mathematics; but the majority begin with an elementary course, for which this work is not suited, and in the more advanced classes, separate books upon the various subjects are indispensable. The chapters on electricity and magnetism are very incomplete, and contain no reference whatever to recent knowledge; and while we cannot expect to find any account of practical applications, the elementary scientific principles which underlie the telephone and the dynamo might at least be referred to.

General students will find one or two sections of considerable interest, *e.g.*, a chapter on the theory of contours and triangular co-ordinates, and some notes on fluid motion and dilatancy.

Electric Lighting for Marine Engineers. By SIDNEY F. WALKER. (London: Tower Publishing Company. 1892.)

Although the aims of this book, as set forth in the preface, are modest, since young electrical engineers are addressed, the author discusses the whole subject of electric lighting, together with an elementary introduction. He advises the use of belt driving from engines running at 200 to 250, and recommends a regulating apparatus, since "it is a very difficult thing indeed to compound machines exactly." The few observations on alternate current work are rather misleading. The old wooden lampholders with looped wire springs are described with hardly a word of warning; and this in a book on ship work! Twenty illustrations of lampholders and forty-one of switches, many of them having been invented by the author, are no indication of completeness or even value. The chapter on measuring instruments does not contain a word about the spring control which is essential for ship work. The Cardew voltmeter is dismissed in seven lines as "quite unsuitable for 'board ship' work." As a matter of fact, though not perhaps the best for this purpose, it is the only one of those described which would be any use at all on board ship. The book as a whole is sadly old-fashioned and full of errors.

Blowpipe Analysis. By J. LANDAUER. Translated by J. TAYLOR. (London: Macmillan and Co.)

This little book is very clearly written. The arrangement of the contents leaves little to be desired, and the illustrations are good. Students already in possession of one of the modern large works on qualitative analysis will not find much with which they are unfamiliar, but to others the work should prove of value, more especially as examples for practice are included. The tables at the end, giving a condensed view of the blowpipe reactions, will be of use to all.

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NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 93.*)

11. Picking-up Gear.—Having glanced at the tanks, and formed some idea of their capacity for different types of cable, we should now, as the ship is supposed to be nearly up to the fault, spend the rest of our time on deck. Here the cable is still coming inboard, and our attention may well be given for a few moments to the action of the steam picking-up gear. This is fixed forward of the bridge, and in some ships is placed upon, and in others immediately below the upper deck. Space is always a consideration on board, and the gear is usually of very compact design, so as to take up as little room as possible. On this account it will be found to require some close observation to understand and appreciate the uses of every part of the gear.

The large winding drum and the various shafts, cog-wheels, and pinions are all seen revolving in their respective positions, and there are various levers and hand-wheels used either in controlling the brakes, varying the speed of the drum, starting or reversing the engines, or throwing in and out of gear. For the purpose of examining the principal parts composing such gear,

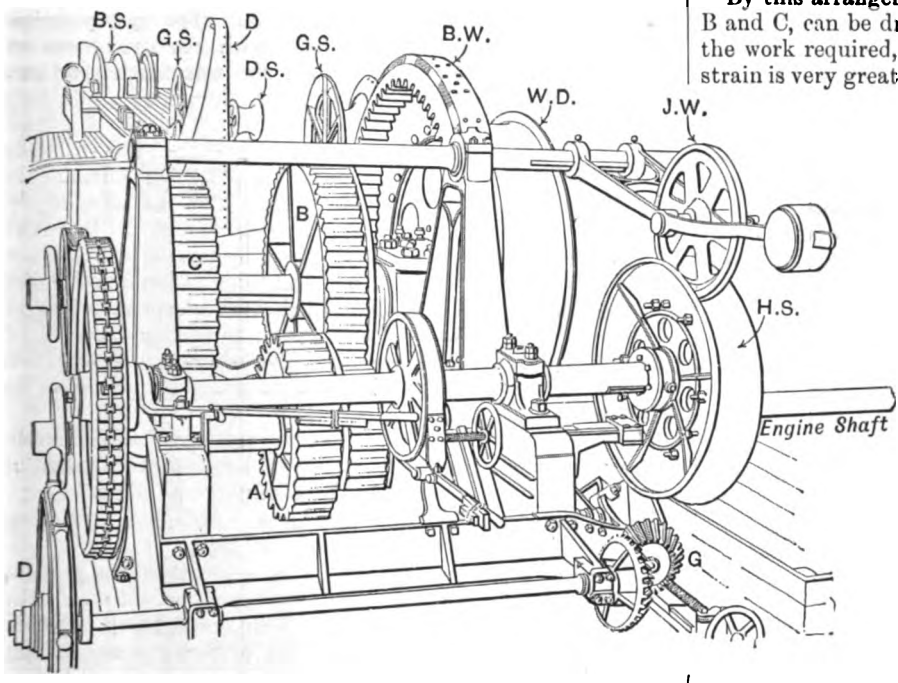

FIG. 34.—Picking-up gear on cable ship "Dacia."

an illustration is given in Fig. 34 of the picking-up gear used on board the cable ship "Dacia," belonging to the India Rubber, Gutta Percha, and Telegraph Works Company.

This perspective view takes in all the machinery as far as the bows, and the path of the cable from the bows to the tank can be well traced. The cable comes in over the bow sheave B S, then passes over the guide sheave G S, under dynamometer sheave D S, over a second guide sheave, then takes three or four turns round the winding drum W D, and thence passes over the sheave H S to the tank. The gear receives motion rom a small steam engine, which drives the engine shaft indicated in the figure through a speed-reducing gear.

The drum is only required to run very slowly, at most about twelve revolutions per minute, a considerable amount of purchase being obtained by the intermediate train of speed-reducing gear between the drum and the engine. The latter is generally designed to run at 100 to 150 revolutions per minute, and the speed is in some cases reduced by one or two intermediate shafts, with pinions driving spur wheels, and in others by a large wheel on the first motion shaft, and a pinion on the engine shaft driving it. The gear is designed to stand at least ten times the strain it will ever be subjected to, and the strength of the teeth is calculated accordingly. The wheels are generally of good malleable cast iron, but in some of the more modern sets they are made of cast steel, by which four times the strength and one-twelfth the weight of similar wheels of cast iron are obtained. Gear designed with cast steel wheels is, therefore, much lighter, and takes up less room for the same power.

For convenience in dealing with work involving different strains a single and double purchase is always fitted on the gear. The single purchase, of course, runs the drum at the quicker speed, and is used in the lighter strains; while the double purchase is used in the heaviest work and drives the drum at half the speed. In the gear illustrated this is effected by the spur wheels at A, B and C. The pair of wheels at A on the first motion shaft are of different diameters, and are either bolted together or cast in one. They can be shifted together along the shaft, so that the large wheel engages with C, or the small wheel with B, the latter position, as they are shown set in the illustration, being that of double purchase. The shifting of the pair is done by turning a hand-wheel and screw, or lever, causing a fork which engages in a collar fixed to the pair of wheels to travel along the shaft and carry the wheels with it. The wheels skid over a long key or feather on the shaft.

By this arrangement the drum shaft, on which are the wheels B and C, can be driven at two convenient speeds, according to the work required, while the engine speed is the same. If the strain is very great, as in heaving up cable from 2,000 fathoms, the slow gear is put on, a greater purchase is thereby attained, and a greater load can be lifted by the engine, because it now lifts it slower. The same thing would not, of course, be attained by slowing down the engine, since that would mean a decrease of power consequent upon either an earlier cut off in the cylinder, or a decrease in the volume and pressure of steam admitted. This change from single to double purchase is, of course, only made when the engine and gear are at rest. It can generally be judged before starting which gear is best suited to the work in hand, but if while the gear is working it is thought better to run on the other purchase, it is a simple matter to put on the brake and slow down the engine at the same time, and when stopped shift over and start up again. Sometimes, as in slacking or paying out, it is necessary to let the gear run free of the engine altogether and use the brake, in which case the pair of wheels can be put to the intermediate position between B and C when they are not in gear with either.

The brake wheel is on the same shaft as the drum, and is about 7ft. in diameter. Outside it (as shown at B W) is the brake strap, consisting of a band or hoop of flat iron with wood blocks screwed on at intervals. The blocks bear on the face of the wheel, and the friction on the same can be regulated by tightening gear, which closes up the band. In the figure the hand-wheel for regulating the brake is shown at D, the motion to this wheel being transmitted to the brake band by two bevel pinions on the right. The lower half of the brake-wheel revolves in a tank of water.

As the cable comes in past the drum, it is necessary to keep it in a straight line and perfectly taut, or it will not run evenly over the drum. For this purpose it is led over the sheave H S before passing into the tank. Over this sheave is a smaller wheel, mounted in a bracket keyed to a shaft, as shown, and which is weighted by the counterweight fixed at the end of the bracket. This wheel, called the jockey wheel, is chamfered off on both sides of the face, so as to fit easily in the groove of the sheave when the cable is passing over it, and its duty is to exert a pulling action on the cable in the direction in which it is moving, and so keep it from slipping back or sagging. In order to effect this properly, the sheave H S is driven a little faster than the drum, so as to draw the cable off the drum and

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keep it taut. That is, the circumferential speed is a little greater than that of the drum. For example, if the drum was 18ft. in circumference, and ran at 10 revolutions per minute, the cable would leave the drum at a speed of 180ft. per minute, and the jockey sheave would have to take charge of it, and pull it in at a little faster speed to keep it taut, say at 185ft. per minute. Hence, if the sheave had a circumference in the groove of 5ft., it would have to be geared to run at 37 revolutions per minute, or nearly four times the speed of the drum. Of course the sheave slips past the cable a little, due to the slight excess of speed, but by this means, together with the weight of the jockey wheel riding on it, the cable is kept perfectly taut. The jockey sheave is always run by gearing off the drum shaft, not the engine shaft, as thereby the ratio of speed between the drum and jockey is maintained the same, irrespective of the intermediate gear between the engine and drum. This will be noticed in the illustration, where the shaft on which the jockey or hauling sheave is mounted is driven by a pitch chain wheel on the left-hand side. The further chain-wheel, which drives the above, is keyed to a shaft driven by a pinion gearing into the teeth on the inside of the brake wheel. By this means the necessary speed of the jockey sheave is obtained, while at the same time the brake wheel, being on the drum shaft, imparts to the jockey, through the pitch chain gear, a speed bearing a constant ratio to that of the drum. After leaving the jockey sheave the cable passes down into the tank through an eye fixed to a piece of timber across the hatch (Fig. 35). This is of use in both coiling in

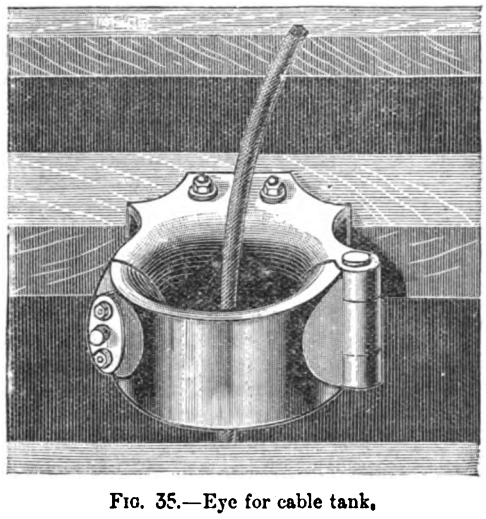

Fig. 35.—Eye for cable tank.

and paying out cable, in keeping it exactly over the middle of the tank. The eye is cast in two halves, one half being bolted to the cross timber, and the other hinged to it, so that it can be opened at any time, when it is required to slip cable out. This is necessary, for instance, during paying out, if it is required to change over and pay out from another tank.

Further, with reference to the jockey gear, it may be mentioned here that when paying out either grapnel rope or cable over the bows, it is necessary that the cable or rope should be held back, in order to feed it taut on to the drum from the tank. The jockey-pulley and sheave perform this duty also; but in this case, contrary to the conditions in picking-up, the circumferential speed of the jockey-sheave must be *less* than that of the drum, in order to hold the cable back. This is effected by throwing the jockey-sheave out of gear with the drum, and putting on a small brake. In the illustration the lever for putting the shaft out of gear with the pitch chain-wheel is shown at the left end of the shaft, and the brake wheel is seen mounted on the shaft about midway. The lever of the brake is set once for all to give the right amount of check or back pull on the cable as it advances towards the drum during paying out.

When cable is payed on to a drum, taking a few turns round it, it is necessary to fleet the turns or shift them constantly sideways, in an opposite direction to that in which the cable tends to coil itself on the drum. If this were not done the cable would wind itself across the drum until it reached one side, and then bank up and override the previous turns. To prevent this the fleeting knife is used against the drum, as shown in Fig. 36. The knife is of cast iron, having bolted to it on one side the curved part B, which bears against the cable. It is set close against the drum on the side on which the cable leads on, and as the drum revolves it keeps the turns constantly in the same position, and allows the cable to feed on continuously in the same place. This will be understood by reference to the figure, where the direction of winding of the cable is indicated by arrows. The knife is generally mounted on a sliding bed, so that by turning a screw (A) it can be withdrawn from the drum while the first few turns of cable are being put on. Again, if cable is led on to the drum on the other side, as in paying out, the knife is required on the other side, and the same can be shifted to the left along the bar D, by slacking the set screw C. Also the curved piece, B, can be unbolted and shifted from the left-hand side and bolted up again on the right-hand side, so as to bear against cable on the other side. In some ships—as, for instance, on the Eastern Telegraph Company's vessel, the "John Pender"—the more convenient arrangement of two knives is provided (Fig. 37), either of which can be moved up to the drum face and the other removed by the screws A A, according to which side the cable is first led on to the drum. The first occasion on which the fleeting-knife was used with the drum was on board the original "Monarch," when she was first rigged out

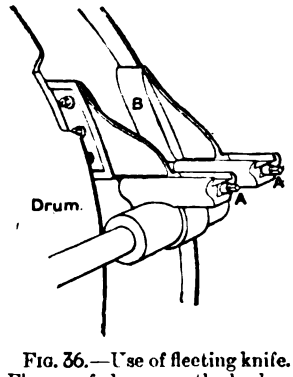

Fig. 36.—Use of fleeting knife. Flange of drum partly broken away.

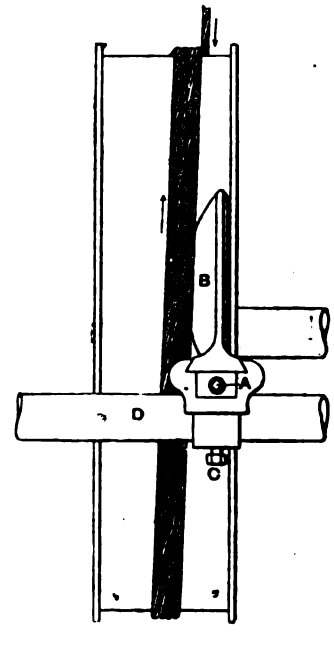

Fig. 37.—Mounting of drum knives.

to lay the Hague cables in 1853. Mr. F. C. Webb, in his interesting "Old Cable Stories Retold" (*The Electrician*, Vol. XIII., page 56), details the development in the arrangement of gear on board this 500-ton paddle steamer, which was the first cable ship fully equipped, and after whose name the present cable ship belonging to the General Post Office was christened. Mr. Webb points out that the fleeting knife, drum, and brake were made to the designs of Mr. R. S. Newall, of the firm of R. S. Newall and Co., of Sunderland, who served and sheathed the cores of the four Hague cables, and supplied the skilled labour on this the first expedition of the "Monarch." The knife had been used previously in collieries in connection with cable drums, but its first employment in submarine cable work was due to Mr. Newall. As the result of four years' work on board this vessel, Mr. Webb had gradually evolved and organised the system of picking-up and paying-out gear, cable buoys, mushroom anchors, bridles, and grapnels, the originals of those in use at the present day.

(To be continued.)

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THE USE OF WATER-POWER FOR ELECTRICAL PURPOSES.

BY NORMAN F. WILSON.

In this and one or two subsequent articles we wish to give our readers some information on the subject of water-power in general, and its use in generating electricity for lighting and other purposes.

We consider this subject a most important one for electrical engineers, because cases are constantly occurring where the utilisation of water-power allows of schemes for electric lighting, &c., which would not be otherwise possible; and the rapid strides which are being made in transmitting power by electricity render serviceable many sources of water-power which are now quite useless, owing to their distance from factories or railways.

In the first of these articles we shall deal with the measuring of water, size of pipes for various quantities, horse-power to be obtained from different quantities and falls; and in the succeeding ones we shall describe two or three of the most important types of turbines. The Papers will not be severely technical; but will, we trust, be useful in enabling electrical engineers to observe for themselves when there is a likelihood of their being able to use water-power, and in serving as a guide to them in their choice of a motor.

No. I.—*Measuring Water.*

At the outset of this part of our subject we would caution our readers against guessing at the quantity of water running down a stream or millrace. It is an unwise thing for anyone to do, and often leads an engineer into difficulties. It is always best and most satisfactory to obtain some reliable measurements, even at the cost of a little time and trouble.

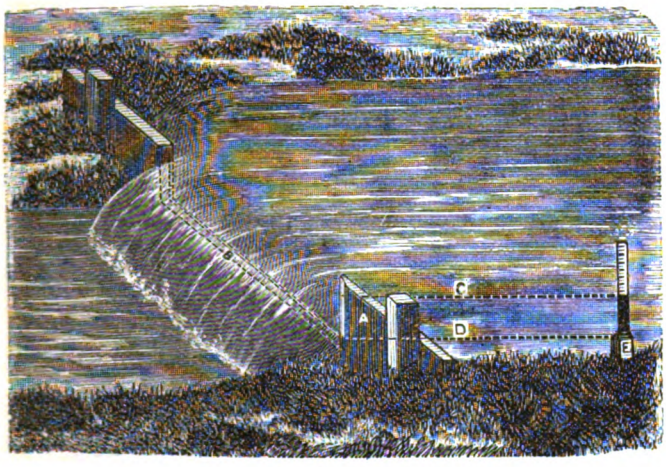

FIG. 1.

Whenever possible, with streams of moderate width we would recommend the practice of stemming the water back with a wooden dam (*see* Fig. 1), unless it is already running over a weir, or through a sluice, where it can be measured.

The planks forming the dam must have a rectangular notch B cut into them, over which the water escapes. This notch should be about two thirds the width of the stream, and the edges of the planks must be bevelled as shown, so that the water meets with no impediment. The dam must be set so that the notch is quite level, and should be high enough to impound sufficient water above it to prevent the possibility of its approaching the notch with any appreciable velocity.

A dam of this description is very easily fixed. A couple of stout pegs must first be driven into each bank, and planks laid across and stemmed with clay or sods weighted with stones. Next drive in a peg E, two or three feet higher up the stream until the top is level with the notch B. The height of water over the notch must be measured from the peg, and *not* at the notch itself, as the water begins to fall as it flows over.

By careful experiment the water (in cubic feet per minute) flowing over each foot of the notch has been found equal to $5{\cdot}15\sqrt{h^3}$, where h = height in inches; and the accompanying table has been worked out from this formula:—

Gauging Water over a Notch.

Height of water above sill.	0	¼	½	¾
0	0	·64	1·82	3·34
1	5·13	7·2	9·46	11·9
2	14·6	17·4	20·3	23·5
3	26·8	30·2	33·8	37·4
4	41·2	45·1	49·2	53·3
5	57·6	62	66·5	71
6	75·7	80·5	85·3	90·3
7	95·3	101	106	111
8	116	122	128	133

Thus, if the sill be 4ft. 6in. wide and there are 3½in. of water flowing over it, we have

$$4{\cdot}5 \times 33{\cdot}8 = 152{\cdot}1 \text{ cubic feet per minute.}$$

Another method of calculating the water in a stream or race which has a fairly regular section is as follows:—First measure a distance down the bank, say 20 yards long, and see how long a stick or bunch of grass takes to float down. This should be done two or three times, and the average speed recorded. This speed will be that at the centre on the surface, the *mean* speed of the water will only be four-fifths of this, owing to the friction of the bottom and banks. Next find the area of the cross-section of the stream. The quantity of water Q (in cubic feet per minute) is then equal to the mean velocity in feet per minute × the area in square feet. For example:—What quantity of water is flowing down a stream with a rectangular channel 7ft. 6in. wide × 1ft. 6in. deep, flowing at the rate of 2·5ft. per second on the surface?

$$\text{Area} = 7{\cdot}5 \times 1{\cdot}5 = 11{\cdot}25;$$

$$\text{Mean velocity } V = 2{\cdot}5 \times 60 \times \tfrac{4}{5};$$

$$Q \text{ in cub. ft. per min.} = 11{\cdot}25 \times 2{\cdot}5 \times 60 \times \tfrac{4}{5} = 1350.$$

When practicable, when there is any question of the water supply being deficient in dry weather, the stream should be measured over a period of some weeks, in order that the greatest, average, and least quantity flowing may be ascertained.

This will prevent any disappointment, and will enable the turbine manufacturers to put in a machine suited to the circumstances. In such cases the wooden dam is much the best, as the water can be measured two or three times a week, without any trouble, by an ordinary labourer; and a dam of this sort will remain in position for months if it be not tampered with.

After having measured the water it is very easy to find what power it will give with any fall.

It is obvious that a cubic foot of water falling a given number of feet will, neglecting friction, either raise another cubic foot an equal number of feet, or do an amount of work equal to this. A cubic foot of water weighs 62½lbs., and the power it will give for each foot of fall is therefore 62½ foot pounds. If we multiply the number of cubic feet by the fall in feet and by 62½ we get the number of foot pounds of work that a given quantity of water falling a given number of feet will do, and this result divided by 33,000 will be the theoretical horse-power; or,

When F = Fall in feet,

Q = Quantity of water in cubic feet per min.,

$$\text{H.P.} = \frac{F \times Q \times 62\tfrac{1}{2}}{33{,}000}.$$

A well constructed turbine will give 75 per cent. of this power, and a water wheel from 50 per cent. to 66 per cent.; the latter is therefore not nearly so economical as a turbine.

Allowing 75 per cent. efficiency our formula becomes:—

$$(a)\quad \text{H.P.} = \frac{F\,Q}{706},$$

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or with 66 per cent. efficiency,

$$(b)\ \text{H.P.} = \frac{\text{F Q}}{802}.$$

In other words, in (*a*) 706 cubic feet per minute, and in (*b*) 802 cubic feet falling one foot will give one brake horse-power. For example:—What horse-power can be obtained from 500 cubic feet with a fall of 23 feet?

In this case Q = 500,

F = 23,

$$\text{by } (a)\ \text{H.P.} = \frac{500 \times 23}{706} = 16{\cdot}28.$$

With a water-wheel we should only obtain

$$\text{by } (b)\ \frac{23 \times 500}{802} = \frac{11{,}500}{802} = 14{\cdot}34\ \text{H.P.}$$

Besides the waste of water in a water-wheel the disadvantage of its slow speed is so great that we shall ignore it altogether as being quite unfitted for electrical work when a new plant is to be designed, and shall only deal with turbines.

Pipes.

When the fall is more than 10 or 12ft., the water is usually conveyed to the turbine in cast or wrought-iron pipes.

When there is a considerable length of pipes they should be kept as small as possible to reduce the cost of the installation. If, however, they are made too small, it takes a considerable portion of the head to overcome the friction of the water flowing through them at a high speed; and if the pipes become furred in the course of a few years they will not deliver enough water, and the turbine will give proportionally less power. This, of course, is not the fault of the turbine, but of the pipes.

The accompanying table shows what various sized pipes will deliver with a loss of 9in. of head per 100ft. of pipe; the velocity of water in feet per second in each case; the initial loss of head in producing this velocity; and the weight per yard of pipes suitable for falls up to 200ft. The loss of 9in. in 100ft. may be more than can be spared for large pipes with low falls, but the figures given will serve as an approximate guide:—

Flow of Water in Pipes.

Diameter of pipe in inches.	Cubic feet per minute.	Velocity of water in feet per second.	Loss of head in producing velocity.	Weight of pipe per yard.		
				cwt.	qr.	lb.
5	23	2·9	·13	0	2	14
6	37	3·2	·16	0	3	5
7	55	3·5	·19	0	3	24
8	79	3·75	·22	1	0	14
9	106	4·0	·25	1	1	9
10	139	4·25	·28	1	2	12
12	218	4·7	·35	2	0	0
14	325	5·1	·40	2	2	0
15	386	5·3	·44	2	3	2
16	454	5·5	·48	3	0	9
18	615	5·8	·53	3	3	15
20	810	6·0	·56	4	1	0
24	1,280	6·8	·72	6	1	0
27	1,770	7·3	·83	7	0	0
30	2,270	7·75	·94	8	0	0

Let us take an example:—200 cubic feet of water has to be conveyed 120yds. What sized pipe should be used, and what will be the total loss of fall? From our table we see that a 12in. pipe will be suitable, and that the loss in friction at 9in. per 100ft. will be $\frac{9 \times 360}{12 \times 100} = 3{\cdot}24$ft.

To this must be added ·28ft., the fall necessary to give the water a velocity of 4·7ft. per second. The total loss will therefore be 3·24 + ·28 = 3·52ft.

N.B.—In working out the horse-power available it is always necessary to take the *nett* fall.

(To be continued.)

SAFETY FUSES.

BY CLARENCE P. FELDMANN.

Immediately after sending you my article on Safety Fuses* I at last succeeded in getting Vol. VIII. of the *Centralblatt für Electrotechnik*, where the experimental results of A. Reinisch† and M. Grassot‡ are reviewed by Herr F. Uppenborn.§

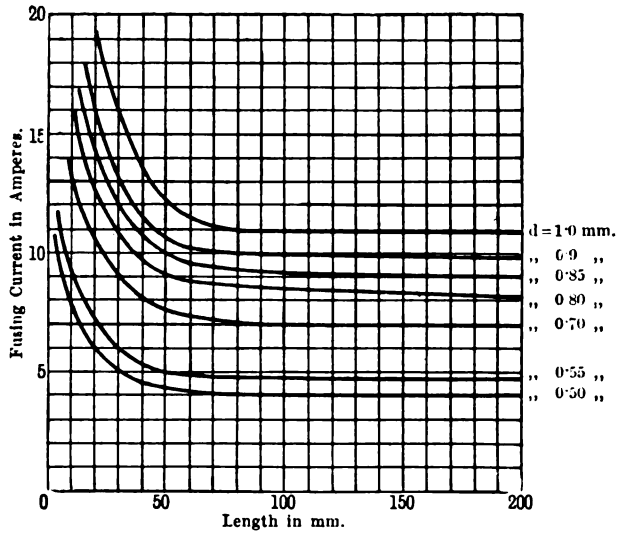
The following Table contains the values of the fusing current which Reinisch observed for lead wires of 2mm. diameter, together with values calculated from the empirical relation

$$C^2 \sqrt{l} = 15{,}250 = 1{,}906\, d^3 \ (d \text{ in mm.}). \quad . \quad . \quad (1)$$

Currents necessary to fuse lead wires of 2mm. diameter and l mm. length.

	Observed by Reinisch.	Calculated from (1).
l = 10mm.	87·35	69·5
20 ,,	66·84	58·5
30 ,,	56·80	52·7
40 ,,	50·01	49·0
50 ,,	46·91	46·4
60 ,,	43·60	44·4
70 ,,	41·24	42·6
80 ,,	40·01	41·2
90 ,,	39·38	40·1
100 ,,	38·74	39·0

The calculated values are very much lower than the observed ones for lengths less than l = 25mm. or so, but certainly for the rest of the table the observed and calculated values agree sufficiently well. Reinisch himself wanted to prove Joule's law



Grassot's experiments.

by his measurements, and concluded that the product $C^2 l$ ought to be constant, but in 1886 already Uppenborn pointed out that, firstly, from Reinisch's experiments $C^2 l$ was not constant, and, secondly, that these experiments only showed the cooling influence of the terminals, and that they were no proof for or against Joule's law. The terminals which Reinisch used must have been rather massive, as is shown by the formula

$$C^2 \sqrt{l} = 1{,}906\, d^3,$$

which gives

$C = 12{\cdot}44\, d^{\frac{3}{2}}$ for l = 150mm and d measured in mms. (1ª)

against Mr. Preece's value

$C = 10{\cdot}77\, d^{\frac{3}{2}}$ for l = 150mm. and d measured in mms. (2).

whilst for l = 150mm. and the different diameters of lead wires which Grassot tested, the fusing current would come out very nearly coincident with Mr. Preece's value, namely,

$$C = 10{\cdot}4\, d^{\frac{3}{2}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3ª)$$

* See *The Electrician*, May 27, p. 87.
† *Zeitschrift für Electrotechnik*, Vol. I., p. 243 (1883).
‡ *L'Electricien*, Vol. X., p. 420 (1886).
§ *Centralblatt für Electrotechnik*, Vol. VIII., p. 421 (1886).

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being a special value for $l = 150$mm. of the empirical relation

$$C^2\sqrt{l} = 1{,}267\ d^3 \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Grassot's results are laid down in curves very much resembling the first series of curves in my article. From these curves I took the following "observed" values, and placed them together with those calculated from the following empirical formulæ—

For $d = 0{\cdot}5$0mm.	$C^2\sqrt{l} =$	155, or	$C^2\sqrt{l} = 1{,}240\ d^3$	(d in mm.)
$= 0{\cdot}55$,,	,, =	208	,, $= 1{,}250\ d^3$	,,
$= 0{\cdot}70$,,	,, =	446	,, $= 1{,}300\ d^3$	,,
$= 0{\cdot}80$,,	,, =	660	,, $= 1{,}290\ d^3$	,,
$= 0{\cdot}85$,,	,, =	784	,, $= 1{,}275\ d^3$	,,
$= 0{\cdot}9$,,	,, =	918	,, $= 1{,}260\ d^3$	,,
$= 1{\cdot}0$,,	,, =	1257	,, $= 1{,}257\ d^3$	,,
	Mean value of $C^2\sqrt{l} = 1{,}267\ d^3$			,,

Currents necessary to fuse lead wires of d mm. diameter and l mm. length, as observed by M. Grassot, and calculated from formula (3).

l in mms.	$d = 0{\cdot}5$mm		0·55mm.		0·70mm.		0·80mm.		0·85mm.		0·90mm.		1·0mm.	
	$C^2\sqrt{l} = 155$.		$C^2\sqrt{l} = 208$.		$C^2\sqrt{l} = 446$.		$C^2\sqrt{l} = 660$.		$C^2\sqrt{l} = 784$.		$C^2\sqrt{l} = 918$		$C^2\sqrt{l} = 1$	
	Obs.	Calc	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc	Obs.	Calc	Obs.	Calc
10	7·9	7·0	9·1	8·3	13·0	11·9	16·5	14·5	—	15·8	—	17·1	—	19·1
20	6·0	5·9	7·2	6·9	10·5	10·0	12·8	12·2	14·5	13·3	16·0	14·3	19·5	16·5
30	5·0	5·3	6·0	6·2	9·0	9·0	9·9	11·0	12·0	12·0	13·1	12·9	16·0	14·9
40	4·5	4·9	5·4	5·7	8·0	8·4	9·6	10·2	10·7	11·2	11·5	12·1	13·6	13·9
50	4·3	4·7	5·0	5·4	7·6	7·9	9·0	9·6	9·8	10·5	10·5	11·4	12·1	13·1
60	4·1	4·6	4·8	5·2	7·4	7·7	8·8	9·2	9·5	10·1	10·2	10·9	11·4	12·5
70	4·0	4·3	4·7	5·0	7·2	7·4	8·7	8·9	9·3	9·7	10·1	10·5	11·1	12·1
80	4·0	4·2	4·7	4·8	7·1	7·1	8·6	8·6	9·2	9·4	10·0	10·1	11·0	11·6
90	4·0	4·1	4·7	4·7	7·0	6·9	8·5	8·4	9·1	9·1	10·0	9·8	11·0	11·3
100	4·0	4·0	4·7	4·6	7·0	6·8	8·4	8·1	9·1	8·9	10·0	9·6	11·0	11·0
120	4·0	3·8	4·7	4·4	7·0	6·4	8·3	7·8	9·1	8·4	9·9	9·1	11·0	10·6
140	4·0	3·6	4·7	4·2	7·0	6·2	8·3	7·5	9·0	8·2	9·9	8·8	11·0	10·2
160	4·0	3·5	4·7	4·1	7·0	5·9	8·2	7·2	9·0	7·9	9·9	8·5	10·9	9·8
200	4·0	3·3	4·7	3·8	7·0	5·6	8·1	6·8	9·0	7·5	9·8	8·1	10·9	9·4

The calculated values are somewhat lower than the observed ones for values of l under 20mm. and over 100mm., at which point Grassot, in coincidence with my own experiments, found the curves nearly horizontal—that is, showing no more decrease of fusing current for further increase of length. This is more clearly shown by the accompanying figure, which is a reproduction of Grassot's figure of 1886.

A GLANCE AT SOME ELECTRICAL FEATURES OF LONDON.

To see ourselves as others see us is always a healthy and sometimes even an amusing process. We therefore give below some extracts from an article by Mr. Robert M'A. Lloyd, which appeared in the *Electrical World* of May 21st. Our national modesty forbids the publication of any other than the more or less depreciatory portions of Mr. Lloyd's review of the electrical features of the metropolis.

Americans are very apt to talk as if the commercial history of electricity was being made in this country while the professors and doctors of the old world were still playing with it in their laboratories, and so a glance at the electrical business of London has been a great surprise to those who have crossed the water within the past year. The development of domestic lighting in England has been characterised by strides almost as great as have marked American progress in street railroading; and with this electrical engineering, contracting and the supply business have all enjoyed a considerable boom.

The inhabitants spend so little money for heat that they can afford to waste some on light, and they pay almost twice as much for an incandescent lamp as we do in New York in spite of the fact that the price of coal is about the same in both cities.

I visited most of the central stations and learned from the resident engineer of each that his plant was the most economical of all. First there is the great Deptford station on the south-east edge of London, located there to avoid stoppages from injunctions, which are used promiscuously in the metropolis by citizens who object to smoke or noise. One feature of the Deptford station that I have not seen described before is the method of blowing out the arc at the dynamo switches. These are large manual switches, with a double-pole, 4-foot break. While one attendant opens the switch another stands by with an instrument somewhat resembling a canoe paddle, having a flexible leather blade, and with this clubs out the arc. Returning from Deptford one feels quite at home on looking in at Lincoln's Inn Fields, where there is a large and complete Westinghouse plant, engines, and generators all shipped there direct from Pittsburg and giving perfect satisfaction at 1,000 volts. There are about 20 central stations in London, and almost every one possesses important features peculiar to itself. In this one city electrical engineers seem to be trying every conceivable method of making steam, driving dynamos, and transmitting and distributing electric energy, and I found there a great diversity of opinion as to which methods were giving the best results. The lighting companies do not do any inside wiring or sell any fixtures. They merely put on a tap for your house and leave the rest to the contractor, under the supervision of a consulting engineer. In London the consulting engineer asserts himself in a way that is unheard of in New York—in fact, it did my heart good to see so many people living on one job.

Outside the Deptford station the most interesting electrical sight in London is the City and South London Underground Railway. After all there is nothing wonderful about it as a power exhibition except that it is there, and in a land where so little has been done in electric motors. The absence of ventilation is the most conspicuous feature. Mr. Grindle explained to me that the air was so bad above ground that there could be no object in introducing it below. A little air does go into the elevator cars when they are opened at the top of the shafts, and walks out with the passengers at the bottom; but any one whose windpipe has not been already seasoned by the steam roads underground can do nothing but gasp while in these electric tubes. This road, however, certainly demonstrates that electricity is the stuff for underground rapid transit, and that underground roads with ventilation, which is not a serious problem, are a very satisfactory means of getting through big cities. The electrical equipment of the road seemed to be very good, but I was somewhat surprised to find that the engineers did not know how to run compound wound dynamos in parallel. The power is generated by Edison-Hopkinson dynamos built by Mather and Platt, and while the series coils are evenly divided between the two legs of the magnet, those on one side only are used, and only used when the machines are running singly. When the machines are paralleled the series coils are all short-circuited, and the potential is regulated by rheostats. As a matter of fact it is exceedingly irregular.

The only electric street railway to be seen is that of the East Metropolitan Tramway Company on the Barking-road. It is more interesting to an American as a museum than an exhibition. There are six cars operated with E. P. S. accumulators and Immisch motors, but the road has been equipped in a desultory way, and no two of the motors are alike; all sorts of gears are used, and the whole make-up would be called "junk" in this country. The road is not at all a discreditable one, when we recall some of our first attempts on this side of the ocean.

THE CUTTRISS CARBON RELAY FOR SUBMARINE CABLES.*

BY CHARLES CUTTRISS.

Until within a comparatively recent period telegraphy was the most important branch of electrical engineering; but of late years developments in electric lighting, power and traction have been so marvellous and we have become so accustomed to calculate and think of volts and amperes by the thousands and tens of thousands that the mind has to exert itself somewhat to realise that instruments using only the hundred-thousandth of an ampere for a maximum current and a millionth of an ampere for a minimum current, are in daily use, and that by means of them we annihilate time and link together the Old and New Worlds. Nevertheless, this is a fact; and by means of these minute currents communication at the rate of twenty-five words per minute is steadily maintained over the Atlantic cables for hours at a time. That this may be done it has become necessary to abandon to a great extent the old system of manual transmission, and to adopt an automatic mechanical transmitter, so that we can now insure the same perfection as regards the shape of the signals and the required spaces at the end of a twelve or twenty-four hours' run as we had at the start.

A few years ago the public were content to send a message to London and get an answer within an hour; now they can get it in a minute or two; but still the cry is for quicker communication.

* From the *Electrical Engineer* of New York.

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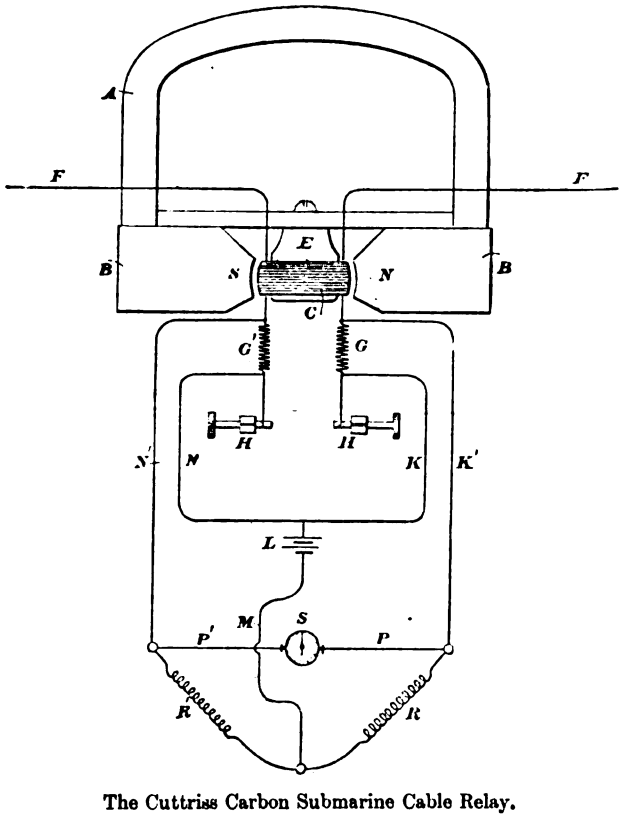
As the adoption of the automatic system of transmission has increased the carrying capacity and speed of long cables to the utmost, we can only hope for still more rapid communication between terminal stations by saving the time now lost in the necessary re-transmission of messages at intermediate stations. This, of course, can be done by interposing a relay which shall automatically repeat into the second cable the signals which come over the first one. As all signals over a submarine cable of any length are of an undulatory character, it becomes necessary that this relay should repeat these undulations into a local circuit as faithfully as a telephonic receiver reproduces the undulations of the diaphragm of its transmitter.

After many failures to attain this end during the last ten years, the instrument shown diagrammatically in the accompanying engraving has been invented by the writer. By its means the connecting in series of a number of short cables of about 800 to 1,000 miles in length, or the connecting of a short cable to a long one is perfectly feasible. Up to the present time a relay known as the Allen and Brown has been practically the only one that would work Morse over cables 500 miles long, and with cables of this length the utmost delicacy of adjustment was necessary to obtain satisfactory signals.

Heretofore there has been no instrument which would repeat recorder signals into a local circuit, thereby making it possible to have several offices in a city working directly on to a through



The Cuttriss Carbon Submarine Cable Relay.

cable after the manner in which Morse instruments at various offices work on to one trunk line. In the spring of 1889 I first obtained reliable recorder signals in a local circuit by means of a repeating relay in circuit with the Commercial Cable Company's Canso-New York cable, the copper resistance of which is 13,600 ohms, with an electrostatic capacity of 233 microfarads and a length of 855 knots; the cable is duplexed, and a battery power of 30 volts is used for signalling.

The relay was crude, and consisted of a coil of peculiar shape, which carried two small carbon discs, and which moved in a magnetic field; this coil was placed in the cable circuit. Opposite to the two discs were carbon points, which were connected in a local circuit to the receiving instrument, consisting of two ordinary 8-inch horseshoe magnets, between the poles of which a small coil carrying the syphon was pivoted, the syphon dragging over the surface of the paper.

When the operator at the distant station sent signals, to my surprise they were recorded on the receiving instrument perfect in shape and character, and subsequent measurements showed that the power in the local circuit was upwards of fifty times as great as the initial cable current. Since then I have experimented in every way to find the best form of contact points, but have finally rejected points of any shape, as the adjustments had to be too delicate and the points showed a great tendency to stick and burn.

I then turned my attention to making helices of carbon, and found that by substituting them for the adjustable points all the troubles incident to sticking and burning were eliminated, and that they gave a variable circuit that is entirely under the control of the moveable coil. The relay now repeats most minutely all the undulations of the cable currents.

The strength of the currents in the local circuit can be augmented to such a degree that the local instrument requires no delicate parts, and can be adjusted by the operator instead of requiring the services of a skilled mechanician.

As will be seen, N S are the poles of a permanent magnet; E is an iron core situated between them so as to concentrate the lines of magnetic force into two fields in which a coil C is pivoted at the top and bottom. Thus far the instrument is a copy of the syphon recorder; but instead of using metal springs, weights or analogous devices, to bring the coil back to zero after it has been deflected by a signal, I have substituted the carbon helices G G', connected to the coil by fibres or otherwise, and it will be readily seen that any deflection of the coil must open one spiral and close the other.

Normally the circuits, M, R', R, K', N', G, G', N, K, and L are so balanced that there is no difference of potential at the extremities of the wires P and P'; consequently, the local instrument S is unaffected. Should, however, a signal be set through the coil C it will tend to close one of the carbon spirals and open the other, thus throwing the local circuit out of balance, and energising the local instrument S to a degree corresponding with the movements of the coil; the amount of the energy thus developed follows the laws of the Wheatstone bridge.

By varying the resistances in the local circuit and the strength of the battery, we can obtain any desired power in the local instrument, and, if necessary, a number of them can be placed in various offices in a city by means of the circuit P P'.

It was while experimenting with this instrument, and observing the perfect manner in which the weak cable signals were reproduced by these carbon helices, that I was led to try them as a telephonic transmitter, and was not surprised to find their action all that could be desired. The results obtained have already been described in these columns by the writer.*

THE LOSS OF CHARGE IN THE NEGATIVE PLATES OF ACCUMULATORS.†

BY DR. M. KUGEL.

The observations and tests recorded in the following notes were made on behalf of the Accumulator Company of Hagen, Westphalia, and refer to cells manufactured at their works, that is to say, to cells on the Tudor system.

The battery consisted of 60 No. 9A cells; each contained five positive plates, 300mm. × 300mm. The guaranteed capacity was 215 ampere hours when discharged at 66 amperes. The normal charging current was 54 amperes. According to the assertion of the firm who had put down the cells, the battery did not show the full capacity, in spite of having had a long overcharge amounting to nearly 100 hours. A test charge gave the following results.

Soon after the commencement of charging, gas was evolved from the negative element. The volts rose tolerably quickly to 135, *i.e.*, about 2·25 volts per cell. During a continuation of the charge, the volts and the density of the acid remained perfectly constant. As soon as charging was stopped the volts gradually fell. A capacity test gave a very bad result; whilst discharging at 25 amperes the volts fell, after about 40 minutes, to 90.

The behaviour of the battery on open circuit was next investigated. The cells were overcharged for a period of several hours, until their voltage remained constant and equal throughout the cells at 2 25 volts per cell. The charging current was cut off at 9 a.m. The voltage measured at the poles then came out as follows:—

At 9: 0 a.m.	.....	135 volts
,, 10: 0 a.m.	.....	104 ,,
,, 11:25 a.m.	.....	101 ,,
,, 11:35 a.m.	.....	96 ,,
,, 11:45 a.m.	.....	95 ,,
,, 12:15 p.m.	.....	90 ,,
,, 3: 0 p.m.	.....	83 ,,
,, 11:30 a.m.	(next day)	78 ,,

Measurements were also taken at regular intervals of the voltage, acid density, and evolution of gas of the individual cells. Whilst the positive plates behaved quite normally, the evolution of gas at the negatives continued for some time after the cessation of the charging current. After a certain period it was noticed that

* *Electrical Engineer* of New York, December 16, 1891.

† Abstracted from the *Elektrotechnische Zeitschrift*.

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the production of gas ceased in some of the cells, the voltage in these cells simultaneously showing a gradual falling off, being at that moment from 1·4 to 1·5 volts. The time at which this occurred varied considerably in different cells. In some gas was given off, and the volts remained at 1·8 to 1·9 for 30 or 40 hours after cutting off the charging current, whilst in general eight or 10 hours was the time taken. The evolution of gas did not cease at the same moment throughout a particular cell, a difference of several hours being observed at different plates. The acid density rose in all the elements equally from about 24·8 B to 25·4 B. When a negative plate was taken out of the cell, and placed in pure sulphuric acid, the gas continued to come off as before. When tested it proved to be pure hydrogen.

So far as appearances went the positive plates were quite normal. The negatives, however, did not present the ordinary metallic grey colour, but appeared whiter, as if sulphated. At the end of the charge metallic grey spots could be clearly seen in the active mass, but after the gas was given off they appeared white again.

The battery was then again fully charged and further tested, current being this time taken out of it. It behaved exactly as before, except that the volts fell off more quickly. Gas began to be given off at exactly the same instant as the volts fell away. The latter took place extremely rapidly, only five to eight seconds being taken whilst falling from 1·8 volts to 0. The pressure remained constant at zero from this point all the time that current was passing through the cell.

The plates in a discharged cell were then replaced by new ones. The cell was then charged and found to have the normal capacity. After stopping the charge the new plates gave off some gas, but not nearly so much as the others. A discharged cell was then filled with chemically pure acid. It behaved exactly as before, the capacity remaining very low. A good cell from another battery was then filled with the acid taken from a bad cell. The negative plates gave off gas after charging, and the capacity which had previously been 177 ampere hours was found to be only 32 ampere hours.

The explanation of the above results is as follows:—The formation of hydrogen at the negative electrodes clearly depends upon an oxidisation of the reduced lead sponge. The reason for this abnormal action is obviously to be sought for in the properties of the sulphuric acid used. Qualitative analysis of about 5 litres of this showed the existence of impurities, consisting of chlorine, nitric acid, arsenic and copper, though only in very small quantities. It is further clear that slight admixtures of other acids cannot cause the excessive oxidisation of the lead sponge, and that the bad effects of the sulphuric acid must therefore be attributed to the metallic impurities. It is well known that metals are far more easily oxidised when impure than when pure. Chemically pure zinc, for instance, is only very slowly dissolved in sulphuric acid. If, however, traces of platinum are present, the action goes on very rapidly, as a local current is set up between the two metals which separates hydrogen at the platinum, and oxygen at the zinc.

It was further shown, by chemical analysis, that the electro-negative metals existing in the acid (*i.e.*, copper and arsenic) after charging were to be found in the lead sponge of the negative plates, whilst the liquid itself was free from them. This conclusion was borne out by the observation that good negative plates of normal capacity in pure acid, when once the deleterious metal had been precipitated on them could not be improved by being placed again in chemically pure acid; and the circumstance that the charged negative plates when placed in pure acid continued to evolve gas, shows that the cause of the evolution of gas had been transferred from the acid to the plates by charging.

The above observations enable us very simply to account for the observed results. The electro-negative metals in the acid at the commencement of the charge are precipitated upon the negative plates. They there set up local currents which liberate hydrogen at the electro-negative metal, and oxygen at the adjacent lead sponge. Of the two gases the latter oxidises the lead, whilst the former is given off. The local current being due solely to the contact between the two different metals is affected very little by the direction which the current through the cell takes. As soon as part of the spongy lead is reduced at the commencement of the charge, the local current causes it to be oxidised again, so that the evolution of gas at the negative plate commences much sooner than usual. A complete reduction of the active mass in the negative plate is, moreover, rendered impossible, and the voltage of the battery remains low, in spite of continuing the charge for an excessive length of time. Stopping the charge has no effect on the local current, and consequently cannot influence the evolution of gas. Discharging the element only influences the fall of volts, in so far as that the sponge is oxidised by the discharging current as well as by the local action. The volts fall more quickly, and gas is given off sooner.

It need hardly be mentioned that no change in the capacity in the proper sense of the word really takes place. The effect of the local current is the same as if a shunt circuit existed inside the cell, the energy expended in which is not reckoned in determining the working capacity. The strength of the local currents may be pretty easily arrived at by measuring the volume of gas given off in a specified time.

CAMBRIDGE UNIVERSITY MECHANICAL SCIENCES TRIPOS.*

REPORT OF THE SYNDICATE APPOINTED TO TAKE INTO CONSIDERATION THE ESTABLISHMENT OF AN HONOURS EXAMINATION IN MECHANICAL SCIENCE.

The Syndicate appointed "to take into consideration the establishment of an Honours Examination in Mechanical Science" report to the Senate as follows:—

The present Syndicate were appointed in consequence of a recommendation contained in the final Report of the recent Mechanical Workshops Inquiry Syndicate. It was there stated:—"The Syndicate are fully aware that the arrangements for the education of the students attending the mechanical department cannot be regarded as satisfactory or complete until provision is made for an honours examination in the subjects taught in the department. At present the only examination in these subjects is the special examination in mechanism and applied science, based on a curriculum wholly inadequate for the more able students of the mechanical sciences." And further, "They are unanimously of opinion that the establishment of an honours examination specially adapted to the scientific training of students in the mechanical department is of urgent importance to the proper development of the study of the mechanical sciences in the University." In these expressions of opinion the present Syndicate fully concur. They have had under consideration (1) the course of study which may appropriately be followed at the University by students who wish to lay a scientific foundation for a knowledge of engineering; (2) the opportunities of instruction which the University offers, by lectures and laboratories, to students of such a course; and (3) the character of the examinations in mechanical science which are held in other Universities. They consider that the wants of students of the mechanical sciences are not met by any of the existing triposes. They consider further that until the subjects of its teaching are embraced in an honours examination the department of mechanism and applied mechanics must have its usefulness much restricted, and they are aware that the want of such an examination deters men from coming to Cambridge who would otherwise be likely to profit by the training in science which the University offers. The Syndicate are of opinion that a curriculum of study in the mechanical sciences, the teaching for which is in the main already provided for in the University, affords proper subject matter for a tripos examination, and they propose that a mechanical sciences tripos be instituted. The Syndicate are of opinion that the general regulations affecting the standing of candidates for the mechanical sciences tripos should be similar to those at present in force for the mathematical and various other triposes.

The Syndicate therefore recommend that the mechanical sciences tripos examination shall consist of two parts, the class list for each being published separately. The first part of the examination shall comprise six comparatively elementary Papers of three hours each on the following six subjects:—(1) Mathematics, (2) Mechanics, (3) Strength of Materials and Theory of Structures, (4) Principles of Mechanism, (5) Heat and Heat Engines, (6) Electricity and Magnetism; together with oral and practical examinations in the following six subjects:—(1) Mechanics and Elasticity, (2) Heat and Heat Engines, (3) Mechanism, (4) Surveying, (5) Drawing, (6) Electricity and Magnetism. The second part of the examination shall comprise two more advanced Papers of three hours each on each of the following four subjects:—(1) Theory of Structures, (2) Heat Engines and Dynamics of Machines, (3) Hydraulics and Geodesy, (4) Electricity and Magnetism; together with oral and practical examinations in (1) Engineering Laboratory Work, (2) Geometrical Drawing and Graphic Statics, (3) Machine Drawing and Design, (4) Applied Electricity.

In the first part of the examination a candidate may present himself for examination in all of the subjects, but he is not expected to take more than five of the written and five of the practical subjects. In the second part of the examination a candidate may present himself for examination in all the subjects, but he is not expected to take more than two of the written and three of the practical subjects. The names of the candidates who pass either part of the examination with credit shall be placed in three classes; the names of those in each class shall be arranged in alphabetical order.

* Abstract from the *Cambridge University Reporter*.

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Schedules Defining the Subjects of the Examination (Part I.).—

Schedule I.

1. In Mathematics the subjects of examination will be :—Trigonometrical solution of plane triangles. Simpler geometrical properties of conic sections. The rudiments of analytical geometry, including equations to the conic sections referred to their principal axes. Fundamental ideas of the differential and integral calculus : differentiation and integration of simple functions : geometrical interpretation of differentiation and integration : elementary applications to plane curves, maxima and minima of functions of one variable, areas, volumes, centres of mass, moments of inertia : simple differential equations.

2. The Paper on "Mechanics" will consist of questions of an elementary character on statics, hydrostatics, and kinematics, together with the simple parts of the dynamics of a particle and of a rigid body, the elementary treatment of distributed forces and the rudiments of hydrokinetics. Candidates will be expected to be acquainted with methods of measuring mechanical quantities and with the use of graphic processes in the solution of problems.

3. The Paper on "The Strength of Materials and Theory of Structures" will deal with the preparation and properties of the chief materials used in engineering construction, the kinds of stress to which materials are subjected in practice and the provision of strength which should be made in design, methods of testing materials for strength and elasticity, the various moduluses of elasticity, the determination of the stresses in the parts of structures, the elementary theory of the strength and elasticity of pieces subjected to stress, with applications to such structures as beams, shafts, boilers, roofs, and bridges.

4. The Paper on "The Principles of Mechanism" will deal with the application of the principles of kinematics and dynamics to mechanism, the analysis of mechanism, the theory of mechanism as a means of transmitting and modifying motion, and the characteristics of the more common mechanical contrivances, the use and efficiency of mechanism in transmitting power, the influence and applications of friction, the theory and methods of governing, the balancing of running parts, and other problems in the kinetics of machines.

5. In the Paper on "Heat and Heat Engines," candidates will be expected to show a general knowledge of the character and effects of heat and the elements of thermo-dynamics, and to be acquainted with elementary applications of thermo-dynamic principles to steam engines and other heat engines. The Paper will also deal with the properties of steam and its action in steam engines, the testing of steam engines, their general construction and typical forms, the combustion of fuel, the construction and action of furnaces, boilers and other appurtenances of engines, the supply of steam to engines, including problems relating to valves, the theory and general construction of other forms of heat engines, such as air-engines and gas-engines.

6. In the Paper on "Electricity and Magnetism," candidates will be expected to show acquaintance with the fundamental parts of the subject, with the methods used in electrical and magnetic measurements, with the apparatus commonly used in the industrial applications of electricity, and with the application of general principles to the discussion of practical problems.

Schedule II. (Practical Examinations).

1. Measurements of mechanical quantities ; friction ; tests of material for strength ; measurement of moduluses of elasticity. 2. Experiments on heat ; tests of heat engines ; measurements of efficiency ; hydraulic experiments. 3. Surveying ; adjustment of instruments ; field operations in surveying, levelling, and setting out ; drawing plans ; estimating areas and volumes. 4. Mechanism ; methods of mechanical construction ; marking out work ; adjustment and use of tools, including the commoner machine tools ; construction of surface plates and other standard pieces ; adjustment of the working parts of engines and other machines. 5. Mechanical drawing, including the drawing of machines from measurement, practical geometry, and the use of graphic methods in the solution of engineering problems. 6. Practical electricity, including electrical and magnetic measurement.

In an appendix, the subjects of examination are given in detail, The following section relates to electricity and magnetism :—

Electricity.—Fundamental laws and principles of electricity and magnetism, with special reference to practical applications ; electro-magnetic system of units ; practical units ; methods of measuring electrical quantities ; magnetic measurements ; magnetic qualities of iron ; the magnetic circuit ; batteries ; storage batteries ; dynamos ; characteristics of dynamos ; types of dynamos for direct and alternate currents ; methods of testing efficiency ; alternate currents ; self-induction and mutual induction ; transformers ; electric transmission of power ; motors ; methods of distributing electricity for lighting and other purposes ; electric meters ; electric lamps ; general methods of telegraphy ; testing of land lines and submarine cables ; telephones.

Subjects of oral and practical examination :—

I. Mechanics and elasticity ; measurement of mechanical quantities ; quantitative experiments in mechanics ; friction ; tests of strength of materials ; use of testing machines ; measurement of moduluses of elasticity ; tests of beams, struts, shafts, &c.

II. Heat and heat engines ; quantitative experiments in heat ; use of the indicator ; tests of steam engine and gas engine ; hydraulic experiments.

III. Surveying ; adjustments of theodolite, level, sextant, &c. ; field operations in surveying, levelling, and setting out ; finding the meridian ; plotting plans and sections ; determination of areas and volumes.

IV. Mechanism ; methods of mechanical construction ; marking out work ; adjustment and use of tools, including the commoner machine tools ; construction of surface plates and other standard pieces ; adjustment of the working parts of engines and other machines.

V. Mechanical drawing, including the drawing of machines from measurement, practical geometry, and the use of graphic methods in the solution of engineering problems.

VI. Practical electricity, including electrical and magnetic measurement.

The report is dated May 23, 1892, and is signed by the following :—John Peile (Vice-Chancellor), J. J. Thomson, J. A. Ewing, P. T. Main, Osborne Reynolds, Horace Darwin, W. L. Mollison, R. T. Glazebrook, W. N. Shaw, J. Larmor, H. F. Newall.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—THURSDAY, JUNE 2ND.

Select Committee on the Electric Railway Schemes.

At the sitting of Sir John Kennaway's Committee on Thursday, last week, a discussion arose as to the possibility of any of the Bills getting through all their stages in the present Parliament. Mr. Littler, Q.C., expressed the opinion that the prospects of the Bills behind the Baker-street and Waterloo scheme were altogether hopeless, as even though they were passed by the Committee, they could not get up to the House of Lords in time to be passed this Session. No doubt, however, the same course would be followed on this as on previous occasions, viz., that the Bills would be brought up again at the same stage at which they were left this year, and, therefore, no damage would be done to anybody, except to the members of the Parliamentary Bar, who would be compelled to take a holiday in consequence of the Dissolution.

Sir MYLES FENTON was then examined against the Bill and in support of the case of the South-Eastern Railway Company, stating that the proposed line would interfere with the contemplated extensions of the South-Eastern Company, and with the prospect of carrying out the projected junctions of the South-Eastern Company and the lines north of London. Beneath the station at Charing Cross on the Craven-street property they proposed to establish a depôt for the delivery of vegetables and fruit for conveyance to Covent-garden, the nearest point to which they now conveyed it being London Bridge. There was also a large Continental parcels traffic for the West End, for which they required special accommodation.

Mr. F. BRADY, the engineer to the South-Eastern Company, and Mr. WOLFE BARRY also gave evidence as to the interference with the South-Eastern Company's property and other engineering details, and in cross-examination the latter gentleman said that electrical locomotion had no doubt reached a high state of perfection and excellence, but it could not be pretended that at present it was able to compete with steam. There was no doubt the time was coming when electrical railways would be more generally used ; but with reference to the proposed line what was wanted was a line by which they could run through trains right from the north of England to Dover.

Mr. EDWARD RYDE, surveyor, having given evidence as to the value of the Craven-street property to the South-Eastern Company,

Sir F. BRAMWELL, consulting engineer to the South-Eastern, said that the carrying out of the Baker-street line would be a serious hindrance to a railway going north and south, which would carry ordinary carriages and engines. Although, no doubt, the proposed line would get some amount of traffic which might or might not—he thought it would not—pay for its construction, whatever it got would be traffic taken away from a railway line which must be provided, and the sanctioning of this line would entitle them to raise a Parliamentary opposition to the scheme of the South-Eastern Company. He did not like to joke before a Committee, but it really looked like "pure cussedness" for the promoters to put the Charing Cross Station where they proposed.

Mr. PEMBER: Does your objection apply to all electrical railways?

The WITNESS: It is not an objection to electrical railways at all. If they would make the line 16ft. 2in. wide they would be able to take ordinary rolling stock along it. He believed in electricity as a source of traction on railways ; it might not be so economical as steam at present, but it might become so hereafter.

Sir BENJAMIN BAKER also gave evidence against the Bill in regard to its interference with the Metropolitan line at Baker-street, and said that he confined his objections to the Bill on that ground only. He was an electrical man himself.

Mr. PEMBER: I know you are ; that is why I am so sorry to see you where you are. As far as the scheme goes for fulfilling what it affects to fulfil you have nothing to say against it.

The WITNESS: I have nothing to say against it except that it interferes structurally with the Baker-street Station.

Mr. SEATON, engineer to the Metropolitan Railway Company, and Mr. BELL, general manager of the Metropolitan, also gave evidence against the Bill ; and the Committee then adjourned, the evidence having been concluded.

FRIDAY, JUNE 3RD.

Mr. LITTLER addressed the Committee on behalf of the South-Eastern and Metropolitan Railway Companies, quoting statistics and calculations to show that the Baker-street-Waterloo line would not be likely to pay, and urging that the evidence had substantiated that so much damage would be caused to existing interests that it ought not to be passed. He was quite sure, he said, that his friend, Mr. Pember, would not be willing to sink his fees in an "elongated pipe" of that description. The scheme was full of doubts and full of experiments, and it would have the effect of going dead against one of the main recommendations of the Joint

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Committee, which said that no line should be sanctioned which would delay the construction of a through line. The scheme, he contended, was marked with every conceivable defect; it had no recommendations on the evidence that had been given, and the only thing that the promoters had to rely upon was the instinctive feeling that it would be a good thing to reduce the numerous omnibuses which passed along the streets, and which everyone who knew the traffic of London would feel to be a desirable thing. Speaking further on behalf of the Thames Conservancy, he pointed out that the Conservators had vested in them certain rights of foreshore which were in dispute between the Crown and the citizens of London; and as the crown of the tunnel would come within six feet of the bed of the river, it would be a considerable interference with their rights, though he did not mean to say that there would be danger from the proposal. They had no power to prevent any works in the waterway, or in the soil beneath, but he asked that a special clause might be given them which would entitle them to such compensation as was represented by the value that the privilege of passing under the Thames would be to the Company instead of the bare value of the soil to the Thames Conservators, which was all that by the common law they would be entitled to.

Mr. FREEMAN then proposed to speak on behalf of the hotels in Northumberland Avenue.

The CHAIRMAN: I thought they were all settled with.

Mr. PEMBER: So they are. It is a positive fact that there is only one word in the clause that is open to objection.

Mr. FREEMAN, however, continued his address, asking that if the line were passed by the Committee, a special protective clause should be given to them on account of the exceedingly difficult and treacherous nature of the soil, the massive buildings in Northumberland Avenue being actually built over the bed of an old stream. In the case of the Victoria Hotel, a sum of over £80,000 had to be expended before any foundations were got in at all.

Mr. PEMBER then replied on the case, and pointed out that the financial prospects of the line were not of that questionable nature which the opponents had sought to make out. If they only carried the 5½ millions of passengers per mile as the Metropolitan Railway Company did in 1867, that would represent a traffic of 15 millions, and with that at an average fare of 2d., or anything like it, it would pay over and over again. To do that they would only need to run 120 trains each way, or 240 trains per day, half-full on the average, which would mean only a nine-minute service. The traffic which went by the existing omnibuses from Charing Cross to Baker-street amply justified them in expecting that at least that traffic would be realised, in addition to which there would be the thousands that came in each day to Waterloo, and to whom the line would prove of especial advantage. Replying to the strictures upon the success of the City and South London line, he said that line carried six million passengers, notwithstanding that it was very poorly equipped with rolling stock. Compared with the present scheme it was very small and inadequate, the tunnel being only 10ft. in diameter, as against 12ft. on the Baker-street line, which would make all the difference in the comfort to the passengers. In fact, with smaller wheels, the line would be able to take a Pullman car, and for low speeds large wheels were not required, they being wanted only for high speeds of 50 or 60 miles an hour on the great through lines. In conclusion, in view of the opposition of the other railways which had contemplated a line across London for so many years, but who had done nothing to realise it, he said the question for the Committee to decide was "Is London to stand still?"

The Committee consulted for some time in private, and on the readmission of the public into the room,

The CHAIRMAN said the Committee were of opinion that the preamble of the Bill was proved. They would give to the Victoria Hotel a special clause of protection similar to that given in the case of the Central London line to the Equitable Insurance Office. In regard to the land sought to be taken from the South-Eastern Company at Charing Cross, if the South-Eastern Company wished to clear up a point which had been raised as to interference with a proposed subway they would reserve their decision until they had heard further engineering evidence. As to the question raised by the Conservators of the Thames, that was a matter of clauses.

Mr. FREEMAN asked that the protective clause should be given to the Grand and Metropole Hotels, which he also represented, which was acceded to.

The Committee then went through the clauses of the Bill, the South-Eastern and Metropolitan Companies having retired from the discussion, reserving their right to oppose the Bill in the House of Lords. After argument, the Committee declined to give the special clause asked for by the Thames Conservators, and finally ordered the Bill to be reported to the House.

The Committee then adjourned till Thursday, June 9th, when they proposed to proceed with the Great Northern and City Railway and the other Bills in the group.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 21, 1892.

The American Institute of Electrical Engineers.—The American Institute of Electrical Engineers met for its annual election of officers on Tuesday last. The report of the Council showed that the total membership has increased to 615, a net increase of 74 for the year. The election resulted in the election of Mr. Frank J. Sprague as president, and for vice-presidents Messrs. A. E. Kennelly, Nikola Tesla, and O. T. Crosby, in addition to the three who held over from last year, namely, Messrs. T. D. Lockwood, Carl Hering, and W. J. Hammer. The choice of Mr. Sprague for president was made unanimous, and although but a small part of the total membership were present to cast their votes, his election will, doubtless, give general satisfaction. Since the organisation of the Institute in 1884, nearly every branch of the electrical industries has been represented in the presidential chair by some one prominent worker, with the exception of the electric railway industry. The telegraph has been represented by Mr. Norvin Green, journalism by Mr. T. C. Martin, educational interests by Prof. Wm. A. Antony, electric light by Prof. Elihu Thomson, and the telephone by Mr. Alexander Graham Bell. At the meeting of the Council just before the election three honorary members were elected, these were Lord Kelvin, Herr Werner Siemens, and Mr. Cyrus W. Field. At the dinner, which took place in the evening, a number of speeches were made by representatives of the different branches of the electrical business. Prof. Geo. Forbes, of London, was present, and made a speech, in which he drew comparisons between the American and foreign methods and progress. He was very outspoken in his opinion that in the matter of electric lighting London was now far ahead of American cities, although in some other respects, especially in electric railroading, the Americans were far in advance of the English and Continental practice.

The Westinghouse Company.—The first annual meeting of the Westinghouse Company since the reorganisation was held at Pittsburg this week (Wednesday). The old Board of Directors, with one exception, was re-elected, an indication that the former policy of the Company will be continued. The report of the president shows that bills payable March 1, 1892, were $461,962, and the accounts payable at the sum of $266,973. The total sales of the Company in the field of electric lighting and power for the period from Jan. 1, 1891, to March 1, 1892, aggregated $3,468,900. Orders taken during March and April of this year amount to $1,576,000. The report showed that the indebtedness had been reduced from $5,398,000 in January of last year, to $1,885,000 in March of this year. The make-up of the Board of Directors shows that in this Company, as in the new General Electric Company, the management is largely in the hands of capitalists and financiers; and it is the general opinion that it would not be safe to make any prediction as to the possibility or impossibility of a combination between the Westinghouse and the General Electric Company during the present year; it should be said, however, that rumours to this effect are persistently denied by officials of both companies, who are in a position to know the actual state of affairs.

NEW YORK, *May* 27, 1892.

The Proposed Chicago—St. Louis Electric Railway.—The proposition to construct a high-speed electric railway between Chicago and St. Louis, upon which express trains drawn by electric locomotives would be run at the maximum speed of 100 miles an hour, has been to a considerable extent regarded as more or less visionary; but the idea is really beginning to assume a somewhat substantial shape. Dr. Wellington Adams, who is at the back of this bold project, has been quietly at work developing his plans and placing the whole affair on a substantial business basis. The entire route has been surveyed, and a line 248 miles in length between the two cities has been laid out, without the necessity of introducing a single curve, and without encountering anything more severe than a 2 per cent. grade. The estimate for the construction of the entire line is now placed at $7,000,000, and it is intended to begin the grading of the line in Christian county in Central Illinois during the month of June. According to the present plans, two power stations only will be built, each of at least 10,000 H.P. capacity, one of them being located close to the mouth of a coal pit containing an almost unlimited supply of fuel, while the other is as favourably situated in close proximity to an extensive water-power plant. These two stations will be located midway between the centre and the extremities of the line, so that from each station will be transmitted the power

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for one-quarter of the line in each direction. It is highly probable that some form of three-phase motor will be employed, and that the potential on the primary mains will be at least 25,000 volts, while that on the motor circuit will be probably 2,000 or 3,000 volts. It is authoritatively stated that the right of way has been obtained for fully 60 per cent. of the line, that property has been secured for the power stations, and that terminal facilities have already been secured in both Chicago and St. Louis. It will be of interest to Englishmen to know that two prominent English electrical engineers have been consulted in drawing up the plans for this bold undertaking, and that they are deeply interested in its progress. Whatever may be the outcome of this pioneer effort at high-speed long-distance passenger traffic by electric motors, the scheme is certainly one which has attracted and still engages the attention of the American public in a very striking and characteristic fashion.

CORRESPONDENCE.

NEWCASTLE CENTRAL STATION COSTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Jackson has been a pioneer in more ways than one, and we should be—I know several who are—cordially thankful to him for his frankness in submitting the station data for the last year to public criticism, as well as to fill notebooks in which such information will be found very useful. There are, however, one or two points to which, if you can spare me the space, I should like to draw attention, and, should Mr. Jackson deign to notice this letter, be glad to have his answer. Leaving outside the question of correctness or otherwise of his system of measuring alternating electrical energy, there appears on page 107 of your issue of June 3rd, some figures as to capital cost, which I take it were given at the discussion on the Paper before the Institution. There it is stated that the capital cost per lamp installed equals 30s. Now in the Paper under the heading of "capital" it is stated that the cost per kilowatt will be £50. Taking 50 watts lamps, that is $\frac{1000}{50} \times \frac{1}{50}$ £ or £2. 10s. per lamp installed; a sovereign more than the figure given in your leaderette. Of course, it may be argued that lamps installed are not lamps supplied; but surely provision must be made for all lamps wired, and in any other case figures are fallacious and unreal. Again, at the end of the Paper, as given in a contemporary (though not curiously enough by you), occurs a sentence, "Also the total cost of the unit sold equals 2·9086d., which includes everything except Directors' fees and *legal charges*."

This figure, however, in the Paper is detailed out, and under the last heading appears:—"General (rent, rates, taxes, *law*, sundry expenses) 0·6807d."

Is this not a discrepancy?

Taking the figure given, however, and looking into the details, we are told that the "cost of the service" amounts to 1·9462d.; but in the summing up, "labour and supervision" appears to be debited only with 0·8163d., whereas all the other items appear as given under their respective headings. If I am not very much astray, the cost per unit sold when corrected by the amount stated will be nearly 4d., and not under 3d.

With regard to the vexed question of alternators running in parallel, there are to-day many engineers of eminence who hold that no published statements are to be found which go to show that any one station having this type of plant is running the units in parallel as an everyday occurrence. Of course it is well known that in various instances it has been done; but even Mr. Wilmhurst, of Exeter, who is, I understand, operating Mordey-Victoria plant, wrote to a contemporary recently and strenuously opposed the practice. Could we not prevail on the respected engineers of the Brush Company to throw some light upon this obscure point, and so help those who often have to press their convictions upon the advocates and users of low-tension and secondary battery plant? So far as the writer is aware, Deptford is the best-known instance of this practice, but being an exceptional case, and it can hardly be cited to back an argument or to support a contention in favour of the alternating system generally.—Yours, &c.,

Liverpool, June 6, 1892. CHARLES H. YEAMAN.

[Our correspondent, in arriving at his figure of £2. 10s., takes a 50-watt lamp as the basis of his calculations. If a 30-watt lamp is substituted, the result will be in accordance with that of Messrs. Heaviside and Jackson. The omission by us of the last paragraph of Messrs. Heaviside and Jackson's paper was due to the fact that the authors had not filled in the important figure referred to, and we were unable to do so ourselves on account of the very discrepancies amongst its component items alluded to by our correspondent. Our efforts to obtain the authentic figure were fruitless.—ED. *E.*]

THE TELEPHONE AND ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was greatly struck when reading your leading article last week with the absurdity of the contention of the telephone companies to possess the exclusive right to employ an earth return.

All telephone companies will shortly be compelled to lay down metallic returns, not only on account of cross-induction from light, power, or telegraph circuits, but also in quite as great a degree by reason of the induction of one earth return telephone circuit on another. It is a well-known fact that much of the disturbance felt on the earth circuits in London is due to cross-induction from other earth circuits belonging to the same company.

That the adoption of the metallic return will entirely obviate all difficulties arising from the induction effects produced by light, power, or telegraph circuits is now beyond question.

In Newcastle, where metallic circuits have been adopted, many of the lines of the telephone company run side by side with post-office wires, and also with electric light wires carrying an alternate current, these latter not being in the shape of a concentric cable. No injurious effect whatever is felt, unless the lines are totally out of balance. The only rational course for the telephone companies to pursue is therefore to convert their earth into metallic circuits as soon as possible, when they will be in a position to hand over the entire proprietorship of the electric cesspool to traction companies without any prejudice to their own interests.—Yours, &c.,

Newcastle-upon-Tyne, June 8, 1892. F. J. MOFFETT.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Wimborne Rural Sanitary Authority invite tenders for lighting the public streets of the town and special drainage district for three years from October 21st. Particulars and forms of tender may be obtained at the office of Mr. M. Luff, Union Offices, Church-street, Wimborne, where tenders are to be delivered by the 21st inst.

TENDERS ACCEPTED.—The tender of Messrs. Paterson and Cooper to instal the electric light on board the training ship "Shaftesbury" for the sum of £1,068, and that of Messrs. Frazer and Sons to supply the necessary boilers and furnaces for £423, have been accepted by the School Board for London.

——— The Southampton Town Council have accepted the tender of the Newton Electrical Engineering Works, Taunton, to instal the electric light at the Public Baths for £324.

——— The Tayler Smith Electric Lighting Company have accepted the tender of Messrs. Shoolbred and Co. for the execution of certain alterations and additions to 53, South Molton-street, W., the amount of the tender being £728.

——— At a meeting of the Dundee Gas Commission on Friday, tenders for the work in connection with the buildings of the electric lighting station to the extent of £3,112. 10s., and in connection with the electric works to the extent of £17,330, were accepted. It has been decided to start with three Lancashire boilers, two engines of 60 H.P., and four of 130 H.P., each coupled direct with a dynamo and on the same bed-plate. Accumulator batteries will be erected at the station to regulate the supply, and also to do

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away with night work. Underground cables will be used, and the plant to be laid down will be equal to supply 5,000 sixteen-candle lamps. The price proposed to be charged is 6d. per unit, or about equal to ⅜d. per lamp per hour.

CHISWICK.—The special committee appointed by the Local Board to consider the electric lighting tenders sent in, are of opinion that a new schedule should be prepared, and it is proposed to call in Mr. Spagnoletti to advise them.

PUBLIC WORKS IN BUCHAREST.—H.M.'s Chargé d'Affaires at Bucharest has informed the Secretary of State for Foreign Affairs that it is probable that tenders will shortly be invited for the execution of various public works for the improvement of that town, such as lighting by gas and electricity, erection of new public buildings, establishment of electric tramways, &c. Such further details as are in the possession of Her Majesty's Government may be seen on personal application at the Commercial Department of the Foreign Office between the hours of 11 and 5 daily.

MR. LEOLINE A. EDWARDS.—This gentleman, formerly of the Brush Electrical Engineering Company (Limited) and the Electric Construction Corporation (Limited), has opened an office at 19, Laurence Pountney-lane, Cannon-street, E.C., where he will carry on business as an electrical and mechanical engineer.

LLANDUDNO.—A very complete installation of electric lighting has recently been carried out at the large hydropathic establishment of "Craigside," by Mr. Wm. Kingsland, A.I.E.E. The plant comprises engine, boiler, and three dynamos, and a set of 55 E.P.S. accumulators, K 19 type. There are about 420 incandescent lamps, from 8 to 25 c.p., some arc lights for the grounds, and electromotors for working the machinery in the laundry, hoist, &c.

MINING MACHINERY.—On Saturday last the Federated Institute of Mining Engineers paid a visit to the works of Messrs. W. T. Goolden and Co., 1, Woodfield-road, Harrow-road, with a view of seeing the electric machinery connected with the application of electricity to mining. A large party, among whom was the secretary of the Institution, Mr. Walton Brown, of Newcastle, joined in the visit, and were received at the works by Mr. W. T. Goolden and Mr. Ll. B. Atkinson. Among other objects of interest the party inspected a pumping plant, consisting of a 15 H.P. Goolden mining dynamo; a three-throw ram pump with 5½in. plungers, 9in. stroke, driven by a Goolden mining motor; a coal-cutting plant, including a 50 H.P. dynamo, coal-cutting machines, terminal boxes, portable cable drums, &c., and a 80 H.P. mining dynamo; part of a plant for driving two pumps, one capable of dealing with 400 gallons per minute, on a 450ft. lift, and driving also a colliery ventilating fan; an electric lighting plant, consisting of a 80 H.P. direct-driven Goolden-Willans set; a complete drilling plant for the ironstone mines to Messrs. Bell Bros., Middlesborough (in construction); parts of the plant the firm are now constructing for Messrs. John Watson and Co., of Earnock, comprising two hauling engines, two lighting dynamos, power dynamos, driven by Westinghouse engines, with a total of 120 B.H.P. In the instrument factory the party inspected the latest patterns of instruments now being made, including Evershed's patent shielded voltmeter, which can be used in central stations close to the dynamo without being affected by the same. A good deal of the plant above enumerated was shown in actual operation, and the party left expressing great satisfaction with all they had seen.

THE KIMBERLEY EXHIBITION.—The South African and International Exhibition, which is to be opened at Kimberley in September, is to be lighted entirely with the electric light. For the extensive grounds of the Exhibition, and interior of some of the principal buildings, arc lamps are to be used. These will be worked from three Manchester dynamos, each for an output of 900 volts, 10 amperes; the total number of arc lamps to be used is 37, each of 2,000 c.p. The interior of the smaller buildings will be lighted with incandescent lamps of 16 c.p., worked from three Manchester dynamos, each for an output of 110 volts, 120 amperes. The whole of the plant both for the arc lighting and incandescent lighting is being supplied by Messrs. Mather and Platt (Limited), of the Salford Iron Works, Manchester.

NEW CLASS OF ELECTRIC LAUNCH.—Mr. Sargeant, of Strand-on-the-Green, Chiswick, is now laying down, at the new Electric Launch Works, Eel Pie Island, Twickenham, an electrically-propelled gig, carvel-built, in bright cedar. The boat is designed to give a mean speed of 6½ to 7 miles an hour, with one charge of about 5 to 7 hours' duration. She will be fitted with an awning, cushions, electric light, electric bell forward, gunmetal rowlocks, and sculls, a balance lugsail forward, and a gibheaded mizen aft. The accumulators being sealed and placed below the water-line form ballast and give greater stability, and the boat can be rowed, sailed, or electrically propelled at pleasure. She is being built to the order of F. W. Hagelmann, Esq., of Granby-street, N.W., and will conveniently accommodate six passengers. This class of electric launch will be very useful for the Upper Thames and canals.

NEW TELEPHONE COMPANY (LIMITED).—We are informed that the canvass has reached a successful termination, a large number of subscribers having been obtained.

BOOK CATALOGUE.—Herr Julius Springer, of Berlin, has just issued a very full catalogue of engineering and electrical works published by his house. The catalogue contains no less than 200 pages, and forms one of the most complete lists of electrical and engineering publications we have seen.

VOLUNTARY WINDINGS-UP.—At a meeting of the shareholders of Anders, Elliot and Chetham-Strode (Limited), held on the 31st ult., it was resolved to voluntarily wind up the Company; and Mr. F. H. Ebsworth, chartered accountant, of 1, Arthur-street East, E.C., was appointed liquidator.

——— The shareholders of the Mining and General Electric Lamp Company (Limited) resolved, at a meeting held on May 24th, that as the Company could not, by reason of its liabilities, continue its business, it be voluntarily wound up; and that Mr. J. H. Hays, of 11, Abchurch-lane, E.C., be the liquidator.

GRANGE SYNDICATE (LIMITED).—Under the failure of this Company the usual summary has been issued. The Company was incorporated on August 1, 1890, for the purpose of experimenting upon and developing a patent process for tanning leather by means of electricity, in terms of an agreement made between the Company and Mr. L. A. Groth, of Tokenhouse-buildings. The nominal capital of the Company was £2,000, and the total subscribed capital £1,660. The liabilities to creditors are £581, and the assets are returned at £1. 17s. 11d., the liabilities as regards contributories being £1,550. The first meeting of creditors was held yesterday.

DISSOLUTION OF PARTNERSHIP.—The dissolution of partnership is announced of Messrs. Kipping and Hooton, trading as the Universal Telephone Company, which business has, as we announced in last week's *Electrician*, been taken over by the National Telephone Company (Limited).

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

May 10, 1892.

8,838. A. E. VIDAL. London. Improvements relating to the application of electricity to spring mechanism.

8,854. J. SMALLWOOD. London. Improvements in fittings for electric light.

May 11, 1892.

8,894. A. E. HARDAKER. Liverpool. A type-writing electric telegraph.

8,956. A. KNOX. London. Improvements in or relating to electro-medical belts and appliances.

May 12, 1892.

8,986. D. RYLANDS. Barnsley. Improvements in mains and conduits for electric cables, and in collars and connections for same.

8,987. P. GERMAIN. Paris. Improvements in secondary batteries and accumulators. [Date applied for under Patents Act 1883, Sec. 103, February 23, 1892, being date of application in France.]

9,002. W. MACPHERSON and A. J. HOWES. London. Improvements in connectors and like appliances for electric lighting and kindred purposes.

9,014. H. J. ALLISON. London. Improvements in storage batteries. (P. Kennedy and C. J. Diss, United States).

9,036. R. BRADLEY, N. L. POCOCK and W. BROWN. London. Improvements in electrical accumulators.

9,056. H. S. MCKAY. London. Improvements in means for electrically giving reciprocating motion.

May 13, 1892.

9,105. C. A. BECK and L. KAMM. London. An improved column-printing telegraph for facilitating the receiving and transmission of messages.

9,108. C. P. SHEWSBURY and J. L. DOBELL. London. Improvements in or connected with electric batteries.

9,110. G. A. NUSSBAUM. London. Improvements in microphones or transmitters.

9,132. H. HOWARD. London. Improvements in heating and welding by electricity.

9,136. R. THORNE. London. Improvements in or relating to electric alarms.

9,142. A. L. FYFE. London. Improved combined building block and electric insulation.

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SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

8,009. POORE. Electric call apparatus.
8,874. BENNETT AND HIDES. Telephones and electric bells.
9,048. COGAN and others. Illuminating road vehicles electrically.
10,832. WOODHOUSE AND RAWSON UNITED (LIMITED). (Preschlin.) Electrical transformers.
10,877. VOYSEY. Hauling electric, &c., cables.
11,004. ROSSEAU. Electric accumulators.
11,016. CALLENDAR. Dynamo-electric machines.
11,048. JOHNSON AND PHILLIPS. Electrical mains.
11,060. GIRAUD. Thermo-electric batteries.
22,657. WATTS. Electrical signalling.
7,954. POORE. Electric call apparatus.
10,843. FERRAND. Regulating electric currents.
11,294. BENNETT. Telephonic exchange signalling.
11,313. BOLTON. Utilising electrical energy, &c., in rock boring.
11,560. HARDINGHAM and others. Galvanic batteries.
12,726. THOMPSON (Lahmeyer and Co.). Electrical armatures.
17,849. LEA and others. Electric light fittings.
18,097. SOUTHER. Galvanic batteries.

1892.

3,030. LAKE. (Consolidated Car-heating Company.) Lighting railway vehicles by electricity.
4,578. CASEY. Electric lamps.
4,691. SCHWEIZER. Secondary electric clocks.
4,244. ENDALL. Ships' telegraphs.
6,050. THOMPSON. (Williams.) Electric conductors.
6,083. SMITH. Incandescent electric lamps.

COMPANIES' MEETINGS & REPORTS.

Electric and General Investment Company (Limited).

The third ordinary general meeting of the shareholders of this Company was held yesterday at Winchester House, Old Broad-street, under the presidency of the Duke of Marlborough.

The SECRETARY (Mr. J. Cecil Bull) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN then said: My next duty is to make a statement to you with regard to the condition and prospects of the Company generally. It is always a pleasant task for the Chairman of a Company, when that Company is in a completely flourishing condition; and I am quite sure that no shareholder who has read through the report of your Board can be other than convinced that your Company is in an extremely flourishing condition. Speaking for myself, as the Chairman of your Company, I must disclaim any active part in the prosperity which has fallen to your lot. It is really owing to the exertions of the other Directors at the Board, and to their large experience, as well as their personal ability, that I am able to take the chair on the occasion of your receiving the report in question. Your Company, of course, occupies a position not different from many other Companies in this large centre of commerce and industry. It is essentially a Trust Company or, say, a promoting Company; and although, of course, it is not every industry, however able the Directors may be, that can produce such a balance sheet, yet, at the same time, the character of our business is such that I think the profit we show is perfectly legitimate. I think you will see, too, that it has been gleaned not so much by the peculiar character of our enterprise as by the ability and caution of your Board. It has been owing largely to the indefatigable efforts of this Board that we have been able to carry to a successful issue several important undertakings. I will not go through the whole of these undertakings, but I will mention this in passing that we show in the profit and loss account that there remains, after paying everything, a balance available for distribution of £28,863. Well, now, gentlemen, you have heard of companies of a financial character such as this one earning large profits, but at the same time you have heard of them embarking on very disastrous enterprises; and as there are large profits to be gained in this business, so there are large losses, and it depends on the prudence of the management whether it is loss or profit. There is a great difference between the character of the securities selected for investment, and it has so turned out that our investments have been very prudently selected. It has been the custom of Boards sometimes to be too optimistic, and to rush into investments when on paper they appeared to have great prospects of profit, whereas a little later on difficulty and disappointment have been the result. Your Directors, however, have tried to follow this course—they have never gone into investments which they have not thoroughly investigated, and they have always looked to the disadvantages as well as the advantages offered. So far, their judgment has been shown to have been correct. Many enterprises have been discussed by the Board, and it is really not a great number—I mean, large ones—that have been selected. The City of London Electric Lighting Company has been launched to a large extent—I may say, almost entirely—by your Company. That was a very large enterprise, which promises to have a very great future. It has the privilege of lighting this great city for 40 years. There will be a great demand for this commodity of the electric light, for which I think you will see a large expenditure, for persons in the city are not so economic in regard to the lighting of their places of business as they are of their private residences. The receipts of that Company will, therefore, be, I think, very large, and consequently I feel sure that that Company will prove a great success to investors in it. Then I come to the next matter which has attracted our attention—namely, the Pioneer Telephone Company. You are aware, of course, that the Government have embarked on a new policy with respect to the telephone. They for years, through the Post Office, placed difficulties in the way of the development of the telephone; but the department have seen that the demand for business purposes for this marvellous invention is so large that it is absolutely necessary for it to withdraw its opposing hand, and not only that, but to come forward and lend its assistance in developing the industry. The Bill before Parliament, which, no doubt, will pass before the Session is concluded, is accompanied by a Treasury Minute, under which the Government authorise the Post Office to spend £1,000,000 on the establishment of trunk lines throughout England. That means that the Pioneer Company, which has been launched under the auspices of your Company, will be the means of bringing out the New Telephone Company, which will establish a twin-wire system of telephone, first of all through the Metropolis and then through the large towns of England, so that all persons who want to do their business in future with their correspondents in their own offices—between their own offices in London and offices in the country—will be able, under this new arrangement, to talk with the utmost facility and ease, without any interruption or delay, exactly as if they were sitting in the same office with the persons with whom they were doing business. In a country the size of England—a country so small as England—you can conceive the enormous development of this industry through such facilities as these. We really have as yet never had the opportunity of using this invention; and you can easily conceive, from the facilities I have mentioned, what an enormous development it is capable of. It was in the full contemplation of all these facts, with great discretion, and after considerable care, that your Board embarked on that work, and I may say that you may look forward to that being a very successful venture. That brings me on to show what is the view of this Board, and I feel sure that it will also be the view of all the shareholders in this Company, namely, that it is not simply our business to make a profit and clear out with that profit, leaving these starvelings—as I heard one of my colleagues say—to run about naked in the streets. It will be our business not only to bring these offsprings into the world, but also to see that they have a proper godfather and godmother, and that they prosper as time goes on. The few enterprises of a large character that your Board have had to deal with have been successful, and that they may continue to be so will be the desire of your Board. We want to see that all the enterprises we are instrumental in bringing before the public shall continue to prosper after they have been started, practically, by our acts. I do not know that it would be my province—it is really not my province, as a matter of fact—to go into the balance-sheet, and I shall, therefore, refrain from that task. Other Directors of the Company are far more expert upon the points of the balance-sheet before you than I am. Although I may, to a certain extent, be able to appreciate the merits of the balance-sheet, yet there is a vast difference between being able to appreciate the merits of the balance-sheet and being able to explain it in a lucid manner. I do not think I need take up the time of the meeting with any long remarks of mine upon the past actions of your Board—in fact, upon the results of the past year's working. The report speaks for itself. It is not long, it makes a few statements, and it refers briefly to the reserve fund that has been established. It also states the total amount for distribution, alludes to the amendment of the articles of association, which we recommended, and which you approved, and it also alludes to the fact that Mr. Emile Garcke, who for many years was connected with the Brush Company, and who was instrumental in bringing that Company into the successful position it now occupies, has assumed the position of Managing Director of this Company. That is a fact upon which I think you are to be congratulated. With respect to the future I will only say a few words. I hope we may have before us in the coming year industries that we shall be able to take up and confidently recommend. If so, I have no doubt we shall be able, under the wise guidance of the present Directors, to bring before you as successful a balance-sheet next year as the one we now submit to you for the past year. You must remember that these are very bad times, and that no company hardly at the present time holds a general meeting without the Chairman having to make some apology for there being either no dividend or a low dividend. On this occasion it is my fortunate position to have to make no statement of that sort. You have to look in this Company to one great industry—that is, the future of the electrical industry of this country. It is an entirely new industry—an industry that our fathers had no idea of; that we, perhaps, fifteen years ago hardly realised would become the great business which it will be, and which our sons perhaps will carry to its full development. There is no doubt that this Company, being early in the field, will gain experience and knowledge, so that, as the industry becomes a growing business throughout the whole country, we shall be able to get into our direction what I will call the plums of the business. The City of London Electric Lighting Company is certainly one of the early plums that have been ripening in this enterprise, and I am sure that others will come. It will hardly be my business to lay before you the sort of general schemes which the Board have, and the things they look forward to as likely soon to occupy your attention; but I may tell you, generally, that we anticipate, in the course of next year, several important questions coming before us upon which we shall be able to take an active part, and that the knowledge which has been gained in the past year will enable us to act with prudence, not only in the interests of the shareholders, but, as I said before—and I lay great stress upon it—with respect to the interests of those who will come to us and pay us profits similar to those which we are now paying to you for putting their

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enterprises on a financial footing. I do not think that I need occupy your time further, and I will, therefore, move :—

"That the Directors' report and statements of accounts to May 31, 1892, with the apportionment of the surplus profit as proposed, be and the same are hereby received and adopted."

Mr. GEORGE HERRING, in seconding the motion, warmly recognised the successful exertions in every way of the Chairman to promote the welfare of the Company. The speaker afterwards explained in detail the various items of the balance-sheet and profit and loss account. He pointed out that the called-up capital amounted to £20,500, and stated that he differed from those who thought that the capital was too small. With a small capital it was easier to earn 10 per cent. without dashing into rash adventures. If, however, they found it necessary to make a call they would do so, but he believed that the shareholders would agree with him that it was better to go on with their small capital than to increase it. As to their investments, which stood at £46,500, they consisted principally of stocks and shares in undertakings which had been launched by the Company. They were stated at cost price, but a valuation had been made at what they considered a low figure, and finding that it was a question of no material difference they had resolved to keep the amount at cost price. They had sold securities for delivery on the 15th inst., amounting to £5,715, and they would continue to realise other investments as opportunity afforded ; but they had no wish to sacrifice their securities at what they considered under a proper value. The reserve fund might appear large, but they could not very well divide a higher rate of profit, for the reason that they proposed to divide all the cash they had.

Mr. J. B. BRAITHWAITE, Jun. (a Director), in answer to Mr. Pritchard, stated that all the securities held by them were believed to be first class, and they were all dividend-paying. No doubt Mr. Pritchard's suggestion would be considered by the Board, and if they saw their way to making an offer of some of the investments to the shareholders they might do so.

Mr. SYDNEY MORSE said he thought that the Board had taken a wise course in putting the amount stated to the reserve fund. He hoped that if any of the investments held by the Company were offered to the shareholders it would be at a price which would give them an advantage.

The resolution was carried unanimously.

The CHAIRMAN then proposed the following resolution :—

"That a dividend at the rate of 30 per cent. per annum for the half-year ending May 31, 1892, making, with the interim dividend of 20 per cent. per annum paid on November 30, 1891, 25 per cent. for the year, be and the same is hereby declared on the capital paid up on the ordinary shares."

Mr. B. H. VAN TROMP seconded the resolution, which was unanimously adopted.

On the motion of the CHAIRMAN, seconded by the Right Hon. Lord CLONCURRY, a dividend of £30 was declared on each of the founders' shares.

Resolutions were afterwards passed, making the dividends payable on the 15th inst., and re-electing the retiring Directors and auditors. A vote of thanks to the Chairman and Directors brought the meeting to a close.

The following is the Report of the Directors :—

The profit and loss account for the year ended May 31, 1892, shows a gross profit on the transactions of the year of £34,379. 4s. 5d. ; and, after deducting all standing charges, there remains a net balance available for distribution of £23,863. 12s. 11d. An interim dividend has already been paid on the ordinary shares for the first six months of the year at the rate of 20 per cent. per annum, and the Directors now recommend the payment of a further dividend upon the ordinary shares at the rate of 30 per cent. per annum for the past six months, and a dividend on the founders' shares of £30 per share. This will leave a balance of £20,863. 12s. 11d., which the Directors recommend should be applied as follows :—£20,000 to reserve ; £726. 0s. 1d. for writing off the preliminary expenses ; £137. 12s. 10d. balance to be carried forward in equal moieties on account of the ordinary shareholders and founders.

The amended Articles of Association recommended by the Directors have been adopted at two extraordinary general meetings of shareholders, and approved by the holders of the founders' shares, and have been registered as the Articles of Association of the Company.

The Directors have appointed as Managing Director Mr. Emile Garcke, M.Inst.E.E., formerly Managing Director of the Brush Electrical Engineering Company.

The Directors who retire this year are Mr. George Herring and Mr. B. H. Van Tromp, who, being duly eligible, offer themselves for re-election. The auditors, Messrs. Rait and Kearton, also retire, and offer themselves for re-election.

It is proposed to make the dividends payable on June 15th.

Consolidated Telephone Construction and Maintenance Company (Limited).

The eleventh annual ordinary general meeting of the Consolidated Telephone Construction and Maintenance Company (Limited) was held at the Terminus Hotel, Cannon-street, yesterday, under the presidency of Mr. C. L. W. Fitzgerald.

The SECRETARY (Mr. Charles Curtoys) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said : Gentlemen, I will now make a few remarks before moving the resolution declaring the dividend and adopting our report. You will observe from the report that the net profit for the year is £7,188. 4s. 8d., to which must be added the amount carried forward from last year, making a total sum of £8,904. 9s. 6d. An interim dividend has been paid on the preference shares of 3 per cent., and one of 2½ per cent. on the ordinary shares, and it is now proposed to pay a further 3 per cent. on the preference shares and 1 per cent. on the ordinary shares, which will make 6 per cent. for the year on the preference, and 3½ per cent. on the ordinary shares. It is with extreme regret that we on this side of the table are obliged to present you with accounts which are not so favourable as on past occasions ; and no doubt you are anxious to know how this state of affairs has been brought about. I will endeavour to explain shortly what has happened, but first I should like to call your attention to the debit side of the accounts. There are several items which will not appear again next year; for instance—Colonel Gouraud £550, Crystal Palace Exhibition £174. 17s. 9d. ; and further, we have had considerable extra expenditure in advertising, stationery, &c., also the establishment of agencies. All these items amount to a considerable sum, which will be saved next year. Your Board, finding the figures unfavourable, decided unanimously to relinquish half their fees for the year ending March 31, 1892, and no doubt the shareholders will be gratified to know this. Gentlemen, you see on the credit side of the account the sum of £6,665. 15s. as profit on manufacturing. Last year it was £9,619. 1s. 3d., and has averaged some £8,000 to £9,000 each year since the year 1885. You will ask why has the profit fallen some £3,000. I will tell you. You will recollect that last year the patents held by the National Telephone Company expired, and consequently the United Kingdom became free ground for anyone to compete for the telephone business. The foreigners, German, French, and Americans especially, were not slow to take advantage of this fresh market, and they one and all started agencies in London and elsewhere, and in addition hosts of small English firms started making telephones. You are aware that we, your Directors, have always endeavoured to manufacture a first-class highly-finished article, at a not very extravagant selling price, but still at a substantial one. Now, what we found was that the foreigners and others began to offer telephones at cheaper prices than we were selling at, and so there was no alternative but for us to reduce our prices also ; and this state of affairs has gone on for the last six months. Unfortunately, our competitors offer telephones for about 20s. to 30s., and of course our customers ask us to supply at about that price also. The result is that we do not sell so many of our high-class expensive instruments, but get orders for a lower-class instrument, which yields a lower profit. Again, many foreign nations have lately put very heavy duties on goods sent out to their countries, and this of course has a detrimental effect on our business. This, gentlemen, is how we account for the falling off in our profits.

The measures we propose to adopt to meet this competition are as much as possible to reduce our fixed charges, if I may call them so, and to manufacture with the greatest economy ; and I may tell you we have splendid labour-saving machinery in our factory, nearly all of which has been acquired by your present Board. We have further established agencies throughout the United Kingdom, and we are now organizing a telephone rental business for private lines, such as from house to stables, and shop to factory, and so on. We hope that this business may prove of a lasting nature, and I believe it will be so, in spite of the enormous competition which is going on for this class of business. One thing I will say, it will not be for want of trying that we shall not succeed. Your factory is in perfect order ; we can manufacture cheaply, and are ready to turn out thousands of telephones. All we want is the public to come for them. I should tell you that the demand by the public has not been nearly so great as I anticipated it would be on the expiry of the patents; but it may come for all that. As to the subsidiary companies, Austria has done well with 325 new subscribers, while Portugal only shows an increase of 65; the financial crisis in Portugal has had a detrimental effect on the business of the Anglo-Portuguese Telephone Company, and the Directors of that Company considered it would be unwise to pay a dividend. The consequence to us is that the Edison-Gower-Bell Company was unable to pay us the interest on our preference shares. In Austria the Government intimated that they intended to buy up our subsidiary Company, the Telephone Company of Austria, a business which we had created during the last ten years. Two colleagues and myself went to Vienna in March and also in October, last year. An agreement has been signed by the Austrian Government, and by it they are to take over the business from January 1, 1893, paying us the purchase-money during the first fortnight in January. When we have received this money we shall take the shareholders into our confidence as to what is to be done with it; events at present point to a return of capital, and it may possibly be a remodelling of our balance-sheet. The law-suit by the Edison-Gower-Bell Company against infringers of our patent in Belgium still goes on, and we are told that some very important decision is now near at hand. I may tell you that it is a decision on a technical point, which point was fought out in Paris the other day, and given in favour of our contention. That the Belgian Courts will hold the same view is to be hoped for your sakes. In conclusion I wish to assure you that your Directors are doing everything in their power to put a more favourable aspect on your business ; and as your interests and ours are identical, you may feel confident that we shall do the best we can for you. The Chairman concluded by moving the adoption of the report and accounts and the declarations of the dividends recommended.

Sir ALEXANDER ARMSTRONG seconded the motion.

Mr. PERRING asked why the Directors offered preference shares to the shareholders, knowing that they were to receive a large sum of money from the Austrian Government next year.

The CHAIRMAN replied that they did so simply because they wanted the money, and because they could not be quite certain that they would get it from the Austrian Government to suit their convenience.

The motion was then agreed to.

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On the motion of the CHAIRMAN, seconded by Mr. H. GRÈWING, the retiring Directors, Messrs. J. H. Buckingham and R. Van Zeller, were re-elected; as were also the auditors, Messrs. J. G. Griffiths and A. E. Green, on the motion of the Chairman, seconded by a shareholder.

A vote of thanks having been accorded to the Chairman the proceedings terminated.

Western Counties and South Wales Telephone Company (Limited).

The seventh annual general meeting of the Western, Counties and South Wales Telephone Company was held on Wednesday at the Grand Hotel, Bristol, under the presidency of Mr. Charles Nash, Chairman of Directors.

The report of the Directors, which will be found below, was taken as read. In moving its adoption,

The CHAIRMAN said he could not help expressing regret that that was probably the last annual meeting of their Company in its separate character, or rather as an independent undertaking. After quoting the paragraph in the report which pointed to the reasons which led to that alteration, he said: Of course the consideration of the terms upon which the amalgamation could be carried out was a difficult matter, and he would say a few words upon it, although it would be premature to go into it, as it would be necessary, as they knew, to hold a special meeting. They had endeavoured to put the favourable features of their concern before the National Company in the strongest light, and they were aided in this by their able general manager, Mr. Lewis, and his assistant, Mr. Prout, and others; and although they did not get such terms as they had hoped or such terms as they thought the value of the Company entitled them to, they were, however, able to modify the views of the National Company, and at length got a better price than they at first contemplated. Under these circumstances he thought it desirable that the proposed terms should be accepted; and although it might be a little irregular, as that was not the meeting for submitting the amalgamation resolution, it was certainly desirable that he should now mention the terms. The National Company were prepared to give a fair percentage on the market value of the Western Counties Company's shares, and when they considered that their ordinary shares had only earned two dividends besides the one which would be proposed at that meeting, he thought the shareholders would see that they would not be at all injured by accepting the proposed terms. Those terms were:—One £5 ordinary share in the National Company, with the dividend to April 30, for 18 ordinary shares in the Western Counties Company. The dividend on the National shares had been at the rate of 6 per cent, and that was equal to 1⅞ per cent. on the par value of the ordinary shares, and to 6¾ per cent. on 5s., which was the average recent quotation for their shares.

Mr. GEORGE WHITE said that he did not see the necessity for the proposed amalgamation, as the Company was now going on very well, and seemed to have taken a fresh lease of life. He then, with the Chairman's permission, read a document sent by the members of the Bristol Stock Exchange to the Board of Directors, which was as follows:—"Stock Exchange, Bristol, June, 1892.—To the Directors of the Western Counties and South Wales Telephone Company (Limited).—Gentlemen: We, the undersigned members of the Bristol Stock Exchange, who are either shareholders in the Company or interested on behalf of clients, have perused the recent circular to the debenture holders and shareholders. We desire to protest against the whole tone of the circular, especially that portion in which the shareholders are practically threatened by their own Directors with a winding up of the Company unless they submit to inequitable terms. We must point out that in stating the 'only courses open,' the Directors should have mentioned that, by calling the necessary meetings of shareholders, authority should be obtained for a further issue of capital, and, as we know, it has been suggested that the National Company might endeavour to block such an issue, we would point out the fact of the National Company's power, arising from their holding of bonus shares for which they paid nothing, makes it unlikely they would attempt to use their power in any such manner. In addition to which we would remind you that the Government have expressed their intention to assist the development of telephone enterprise, and we therefore believe that were the National Company to attempt to inflict such a wrong on this Company, the Government have ample power to bring the necessary influence to bear with reference to the National Company's licences as would effectually prevent such an injustice to the shareholders of a Company which has done so much to develop the telephone in this district. Moreover, we desire to express our opinion that a respectable company of such standing as the National Company would never think of attempting such a coercion. Referring to the report and accounts, which have been just published, we consider that there is no reason why you should sell the undertaking, except upon proper terms; and, seeing that the present revenue of the Company exceeds the income which would accrue to the shareholders under the proposed sale, and that no return is being secured to the Company for its splendid future, we are of opinion that you will best consult the interests of the shareholders by refusing to sell the undertaking upon the present inadequate terms." He felt that such a letter had never before been addressed to a Board of Directors and sent so unanimously as it was by the members of the Bristol Stock Exchange; and he trusted the Board would reconsider the matter, and lay before the shareholders the whole of the alternatives, which would enable them to properly consider the subject.

Much discussion followed respecting the document; and ultimately, Mr. MARK WHITWILL having seconded the motion for the adoption of the report, it was put to the meeting, and adopted.

Upon the proposition of the CHAIRMAN, seconded by Mr. R. CORY, a dividend at the rate of 6 per cent. upon the preference capital for the year ended December 31, 1891, was declared.

A dividend of 1 per cent. upon the ordinary shares was agreed to, upon the motion of the CHAIRMAN, seconded by Mr. FEDDEN.

The retiring Directors, Messrs. M. Whitwill and T. Pole, were re-elected.

Colonel JACKSON, of the National Company, in proposing a vote of thanks to the Chairman, desired it to be known that the local company could not issue fresh capital without the sanction of the National Company. There was an express agreement to that effect, and it was absolutely necessary that the Western Counties Company should appeal to the National Company. He could tell them the Directors of the Western Company had fought for the best possible terms.

The resolution was adopted, and the meeting terminated.

The following is the report of the Directors:—

Capital Expenditure.—The capital expenditure for the year ended December 31, 1891, was £20,956. 14s. 3d., making a total of £185,366. 6s. 5d. to date.

Revenue.—The gross revenue of the Company for the year 1891 was £52,224. 1s. 6d., against £46,860. 15s. for the year ended December 31, 1890. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond December 31, 1891, is £15,548. 7s. 11d., against £14,212. 19s. 1d. brought in from the previous year.

Maintenance.—The whole of the Company's plant has been fully maintained, and, where required, renewed out of revenue. The Company have continued to substitute, at considerable expense, a large amount of copper and bronze wire for iron, which has increased the efficiency and durability of the plant.

Working Expenses.—The working expenses, including maintenance and all working charges for the year 1891, have been £16,685. 10s. 10d. against £13,775. 18s. 1d. for the year ended December 31, 1890.

Dividend.—

Balance of net revenue account	£11,236	17	4
Dividend of 6 per cent. on the paid-up Preference share capital for the year ended Dec. 31, 1891	6,000	0	0
Balance for appropriation, as per statement at end of accounts	£5,236	17	4

The Directors recommend that a dividend at the rate of 1 per cent. be paid for the year on the ordinary shares, absorbing £2.811. 19s. 5d., leaving a balance of £2,424. 17s. 11d., from which will have to be deducted the amount which may be voted for the Directors' fees for the year 1891.

Growth of Business.—The number of subscribers to the exchange system and of private line renters has further increased, and the progress made during the year is considered to be satisfactory. The respective totals at the close of the years 1890 and 1891 were:—

	Exchange.	Private.	Total.
For December 31, 1891	3,268	803	4.071
For December 31, 1890	2,875	712	3.587
Increase in 1891	393	91	484

Mileage of Trunk and Renters' Wires—

Erected up to December 31, 1891	5,753 miles
Erected up to December 31, 1890	5.018 „
Increase representing new business during 1891	735 „

In addition to the above, 191 miles of wire have been renewed during the year.

Trunk Lines.—The Company has increased its trunk system, so that on December 31, 1891, it had 505 miles of trunk pole lines connecting towns with each other, carrying 2,383 miles of wire; against 470 miles of pole lines, carrying 2,182 miles of wire, at the corresponding date in the previous year.

Proposed Sale to the National Telephone Company (Limited).—It is within the knowledge of many shareholders that for some time past a gradual process of amalgamating the Provincial Telephone Companies with the National Telephone Company (Limited) has been in operation. It has been felt by your Directors that either an amalgamation must be effected between this Company and the National Company, or additional capital must be raised to meet the requirements of its important district, comprising the Western Counties and South Wales, for which the approval of the National Company would be necessary. After much discussion the former alternative has been adopted, and terms have been provisionally arranged for the consideration of the shareholders. A provisional agreement is now in course of preparation, which will be submitted to a special meeting of this Company with as little delay as possible. As soon as the provisional agreement has been finally settled full information of the terms of the proposed sale will be afforded to every shareholder by circular or otherwise.

The Post Office.—The Directors have pleasure in acknowledging the continued uniform courtesy of the permanent officials of the Post Office Department.

Retiring Directors and Auditors.—Mr. Mark Whitwill and Mr. Thomas Pole retire, the former by rotation and the latter by ballot, but are eligible for re-election. Messrs. Hudson Smith, Briggs, and Co. retire, but are eligible for re-election.

Taunton Electric Lighting Company (Limited).

An extraordinary general meeting of this Company was held on Thursday last week, to consider an offer made by a committee appointed by the Town Council to purchase the Company's works and undertaking at the price of £9,300.

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Mr. J. H. BALE presided, and, after stating that the meeting was a statutory one, proposed—

"*That the offer of the Taunton Town Council to purchase the Company's works and operations, subject to the approval of the Local Government Board and Board of Trade, at the price of £9,300, be accepted.*"

Mr. WALDEGRAVE having seconded the proposition,

Mr. POTTER pointed out that the offer to purchase the works for £9,300 did not come from the Town Council, but the proposal emanated from the committees representing the Council and the Company, who had discussed the matter and agreed to that sum.

The resolution was carried unanimously, and the CHAIRMAN then proposed—

"*That the Directors be authorised to carry out the said sale in such manner and under such arrangements and conditions as they may think advisable.*"

Mr. KITE seconded; and the resolution having been also carried *nem. con.*, the meeting adjourned.

Elmore's German and Austro-Hungarian Metal Company (Limited).

The first annual ordinary general meeting of the shareholders in this Company took place yesterday at the Cannon-street Hotel; Mr. James Beck, J.P., in the chair.

The SECRETARY (Mr. J. Shurmer) read the advertisement convening the meeting.

The CHAIRMAN, in moving the adoption of the report and accounts, stated that the Directors had been very anxious to meet the shareholders, but it had been impossible to make up the accounts without proper vouchers. As these vouchers were in the hands of an official auditor in Germany in connection with the establishment of the German Company, the accounts could not be made up earlier. They had not, however, been idle while the delay had been going on. Owing to the slow process of the German Company law they did not get their actual registration nor their legal position in Germany until quite the last days of April. They stood now before the shareholders with this business completed. When they formed the German Company they paid them about £12,500, and a large proportion of this sum was in the hands of the former at the time the accounts were made up. The report was, he thought, a plain and unvarnished statement of all that the Directors had been doing, and it brought their affairs up to a very recent date. They considered that Germany was a better field for them to begin operations in than Austria, and they had not thought it advisable to do more than they had done; they thought it would be wise to make their footing good in one country before they moved to any extent in another. At their last meeting he told them that they were negotiating for a factory at a place called Schladern, and this property had since been acquired and completed, and they were at that moment actually at work at it. It was an important structure, standing on a river called the Sieg, and it had an important water privilege—that of a fall of about 16ft. close to their works. The estate had, besides the water power, two capital stone quarries and a brick field. They had filled up the lower story of the main building with tanks and machinery for depositing copper in the form of tubes. They had 40 tanks there, but they were not all at work, as there was some difficulty about the mandrils. They had only been at work four or five weeks since they obtained permission, and part of their working had been for their own purposes—that was, making mandrils from the original ones which they had obtained from other sources. The position of the factory was a very good one, with railway communication within about 800 yards, a road to the station, and an iron bridge across the river for the purpose of their works; the bridge being made and maintained by the railway company at no expense to this Company. They began with 25 orders, and they would find plenty to come in to keep them going. As to profits, an average price of 1s. per pound, which they believed they would realise, would give them about £30 a ton profit, and when they worked up to 20 tons a week, or 1,000 tons a year, that would give them £30,000. They would, however, have to extend their works to reach this point; the works now could only turn out five tons a week. They were not proposing to increase the capital; and the projected conversion of the debentures into preference shares would be an advantageous arrangement for the Company.

Mr. JOHN MACFARLAN seconded the motion, which was carried, after the CHAIRMAN had replied to certain questions chiefly on the accounts.

On the motion of the CHAIRMAN, seconded by Mr. GLADSTONE (a shareholder), the following resolution was carried:—

"*That the capital of the Company be increased to £250,000 by the creation of 25,000 new shares of £2 each.*"

The CHAIRMAN next proposed, and Mr. MACFARLAN seconded the following resolution, which was agreed to:—

"*That such new shares, and the 25,000 shares now unissued of the original capital of the Company, shall be called 'Preference Shares,' and shall be entitled, out of the profits available for distribution in each year, to a preferential dividend of 7 per cent., and also to participate pari passu with the holders of the existing issued shares of the Company in the surplus profits of each year, after a dividend of 10 per cent. has been paid for such year on such existing issued shares of the Company, which shall in future be called 'Ordinary Shares.'*"

The retiring Directors and auditors were reappointed, and the usual vote of thanks closed the meeting.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

LONDON ELECTRIC WIRE COMPANY (LIMITED).—This Company was registered on May 31st with a capital of £50,000, in £5 shares. The objects are: To acquire and take over as a going concern the business of manufacturers of electrical wire and other apparatus, carried on by Thomas Willey and John Willey, under the style or firm of "The London Electric Wire Company," at Playhouse-yard, Golden-lane, in the City of London, and to carry on in the United Kingdom and elsewhere the business to be acquired, and all or any of the following businesses, viz., the manufacture of insulated wires, cables and appliances for telegraphs, telephones, and any other electrical purpose, the fitting up of electric installations for lighting or other purposes, the manufacture of electric motors or other machinery, and the buying and selling of any goods or apparatus in any way connected with the foregoing. The first Directors are Thomas Willey and John Willey, each of whom may hold office for life or until resignation.

ELECTRICITY SUPPLY COMPANY FOR SPAIN (LIMITED).—The annual return of this Company, made up to January 7, 1892, was filed on April 30th. All the shares have been taken up, of which the 100 founders' shares have been issued as fully paid. Upon the remaining 19,900 ordinary shares the full amount has been called, and all calls (£99,500) paid.

ELMORE'S AMERICAN AND CANADIAN PATENT COPPER DEPOSITING COMPANY (LIMITED).—The statutory return of this Company, made up to May 17th, was filed on the 31st. 44,788 priority and 35,000 deferred shares have been taken up, of which the deferred shares have been issued as fully paid. Upon the 44,788 priority shares the full amount has been called, resulting in the payment of £80,319, and leaving £9,257 in arrears.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 11th, was filed on the 19th. The Company was registered on April 6, 1878, with a capital of £450,000, divided into 18,000 shares of £25 each. At the time of making up, 17,000 shares had been taken up, the full amount called upon each, and all calls (£425,000) paid.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to May 20th, was filed on June 2nd. The Company was registered on November 26, 1887, with a capital of £250,000, in £10 shares. At the time of making up, all the shares had been taken up, and 2,132 shares had been issued as fully paid. Upon the remaining 47,868 shares the full amount had been called, resulting in the payment of £478,271. 9s., and leaving £408. 11s. in arrears.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 26th, was filed on June 2nd. The Company was registered on April 29, 1873, with a capital of £1,350,000, divided into 67,500 shares of £20 each. The capital has been changed to £1,500,000, divided into 65,871 shares of £15 each, and 66,258 shares of £7. 10s. each. Of these shares, 64,242 shares of £15 each, and 66,258 shares of £7. 10s. each, have been taken up, the full amount called, and all calls (£1,460,565) paid, while £565 has been paid on 75 shares forfeited.

CITY NOTES, &c.

BELL TELEPHONE COMPANY OF AMERICA.—This Company has declared the regular quarterly dividend of 3 per cent., and an extra 3 per cent. in place of the extra 6 per cent. of last year, labour troubles reducing the profits.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 5th were £782, as against £775 for the corresponding period of last year, being an increase of £7. The total receipts to date, from January 1st last, amount to £18,191, against £16,919 in the corresponding period of 1891, being an increase of £1,272.

COMMERCIAL CABLE COMPANY.—Notice is given that a quarterly dividend of 1¾ per cent. upon the outstanding stock of this Company will be paid on July 1st next, from its net earnings, to all shareholders of record on June 20th. The transfer books will be closed on June 20th and reopened on the morning of July 2nd.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the month of May amounted to £2,132, as compared with £2,163 in the corresponding period of last year, a decrease of £31.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for May, 1892, amounted to £22,000; and from January 1st to May 31st to £104,800. In the corresponding months of 1891 and 1890 the amounts were £114,000 and £105,800 respectively.

MALTA AND MEDITERRANEAN GAS COMPANY (LIMITED).—At the adjourned general meeting of this Company, on Tuesday last, Mr. John B. Paddon, the Chairman, said that in October last some proposals were made to the Governor of Malta by Mr. Preece for the supply of electric light to the military and naval establishments and for the public lamps. The Government were, however, unable to see any advantage to be gained in the adoption of those proposals, and their consideration had been adjourned.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the fortnight ended May 31, 1892, amounted to £3,229, as compared with £2,837 in the corresponding period of last year, a decrease of £392.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 3, 1892, after deducting

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17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,032.

WESTERN UNION TELEGRAPH COMPANY.—The earnings for the quarter just ended show a net increase of $250,000. The net surplus for the year shows an increase of $750,000. The regular dividend of 1¼ per cent. has been declared.

CRICKET AT MALTA.—A match was played at the Marsa, Malta, on the 26th ult. between the Eastern Exiles and the C. S. "Amber" elevens, resulting in an easy victory for the Exiles by an innings and 83 runs. Score :—

EXILES.—A. E. Saunders c Ryan b Greey, 18 ; P. F. Kirton c Mitchell b Greey, 23 ; H. Bean b Pickett, 6 ; H. C. Musters b Greey, 12 ; J. W. Roffey c Gifford b Greey, , 35 ; E. H. Sweeting c Smith b Pickett, 12 ; H. H. Sherlock not out, 36 ; T. Devit b Theobalds, 1 ; F. W. Nosworthy b Greey, 4 ; F. W. Newton c Lack b Greey, 0 ; H. Mitchell, b Theobalds, 6 ; extras, 16—Total, 174.

C. S. "AMBER."—Mitchell c Bean b Saunders 4, c Musters b Bean, 0 ; Smith c Roffey b Saunders 9, b Saunders, 5 ; Poselthwaite b Saunders 2, c Newton b Saunders 1 ; Dr. O. L. Theobalds b Saunders 10, c Newton b Bean, 3 ; Captain R. Greey b Saunders 0, b Bean, 20 ; Ryan b Roffey 2, c Saunders b Bean, 4 ; Pickett c Nosworthy b Roffey 0, c Nosworthy b Bean, 1 ; F. Lack not out 3, b Saunders, 2 ; H. C. Gifford c Nosworthy b Roffey 2, b Saunders, 5 ; Lear c and b Saunders 4, b Saunders, 0 ; Wright b Saunders 0, not out, 0 ; extras, 5 and 9—Totals, 41 and 50.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 1.		Price Wednesday, June 8.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 8.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	48	49	48	49	5 12 3	Jan., Apr., July, Oct.	48¼	..
£2,849,510	Stock	25/0	Do. Preferred	88½	89½	88½	89½	5 17 4	" "	89¼	88¼
£2,849,510	Stock	5/0	Do. Deferred	11¼	11½	11	11½	..	" "	11⅝	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101	104	101	104	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¼	10⅜	10¼	10⅜	7 8 10	Mar., June, Oct., Dec.	10⅛	10⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	105	109	105	109	4 11 9	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	158	163	158	163	4 5 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11	12	11	12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3¼	3⅜	3½	3⅝	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½	11⅝	11½	11⅝	5 19 2	Jan., Apr., July, Oct.	11⅛	11⅛
400,000	10	2/6	Eastern	14¾	15	14¾	15	4 6 8	" "	15	14¾
70,000	10	6%	Do. 6 per Cent. Preference	15¼	15⅜	15½	15⅝	3 16 2	" "	15⅛	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108	111	108	111	3 12 1	May and November	109	108
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 11 9	February & August	109	..
250,000	10	6/6	Eastern Extension	15	15½	15	15½	4 11 10	Jan., Apr., July, Oct.	15½	14⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 1	February & August	109⅜	109
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July ..	104	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb..1900	102	105	102	105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	102⅜	..
180,227	10	2/6	Globe Telegraph and Trust	10½	10⅝	10½	10⅝	5 0 0	Jan., Apr., July, Oct.	10⅜	10⅜
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 18 1	" "	15⅜	15⅛
150,000	10	7/2	Great Northern	18⅜	19¼	18⅜	19¼	4 9 2	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	40	42	40	42	5 19 1	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7	8	7	8	5 6 11	April and October..	7⅜	7⅛
3,381	£100 Cert.	£1⅛	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	5 11 1	January and July ..	3⅞	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	103	107	7 9 7	June and December	..	..
88,321	10	1/0	West India and Panama xd	1½	1⅝	1½	1⅝	..	" "	1⅝	1½
84,563	10	6%	Do. 6 per Cent. 1st Preference xd	9¾	10½	9¾	10½	5 17 1	May and November	10	9¾
4,669	10	6%	Do. 6 per Cent. 2nd Pref. xd	8	9	8	9	6 13 4	" "	..	..
67,007	15	6/0	Western and Brazilian xd	9¼	9⅜	9½	9⅝	6 3 1	" "	9 7/16	9⅜
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred xd	6	6½	6	6½	5 15 3	" "	6⅜	..
30,364	7½	7/6	Do. 5 per Cent. Deferred xd	3¼	3½	3½	3⅝	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105	108	105	108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105	108	105	108	5 11 1	" "	106½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	115	119	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094	Consolidated Telephone Const. & Maintenance	⅛	⅜	⅛	⅜	6 10 10	May and November	..	..
x20,000	£1	4⅜d.	Oriental (11s. paid)	1 3/16	1 5/16	1 3/16	1 5/16	6 8 11	Yearly	..	..
438,984	5	2/6	National	4⅜	4⅝	4⅜	4⅝	6 3 1	June and December	4⅛	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½	13⅝	13½	13⅝	4 7 3	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12⅜	13	12½	13	4 12 4	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	108	110	108	110	4 1 10	January and July ..	109	108⅜
58,000	5	1/0	United River Plate	1½	2⅛	1½	2⅛	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7¼	8¼	9¾	10¼	..	..	10	9¾
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	2½	3½	2½	3½	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	..	5¾	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5½	6	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16	3 9/16	3 7/16	3 9/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16	5 3/16	5 1/16	5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	⅜	1	⅜	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	7½	8	7¾	7¾	..	..	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4	5	4	5	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8¼	9	8½	9	..	..	8 15/16	8 3/16
7,900	£5	7%	Do. 7% Preference	8	8½	8	8½	..	..	8 15/16	8½
42,853	5	..	Westminster Electric Supply (fully paid)	6½	7	6½	7	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	2⅞	3⅛	2⅞	3⅛	..	..	3⅛	2 11/16
69,996	2	6%	Do. 6 per Cent. Preference	2	2⅛	2	2⅛	5 2 7	..	2⅛	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5⅛	5⅜	5⅛	5⅜	5 16 8	January and July ..	..	..
17,139	5	17½	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	12/0	Electric Construction	5⅝	6	5⅝	6	..	..	5 11/16	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅝	2¼	2½	..	..	2 5/16	2⅜
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha &c., Works	19½	20½	19½	20½	6 1 11	February & August	20⅛	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	104	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½	4½	3½	4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼	⅜	¼	⅜	..	..	..	..
78,949	5	2/9⅗	Swan United (£3. 10s. paid)	3½	4	3½	4	9 13 0	May and November	3⅝	3½
36,250	12	36/0	Telegraph Construction and Maintenance	44	46	44	46	5 4 9	March and July....	45½	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103	106	103	106	4 14 4	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½	¾	½	¾	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½	3	2½	3	..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	..	..	..	..
50,000	£10	—	City and South London Railway	2½	3½	2½	3½	—	—	..	..

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NOTES.

The electrical attractions at the Royal Society on Wednesday were much the same as those of the May conversazione. Prof. Vernon Boys again showed his photographs of flying bullets, and announced that he had succeeded in reducing the duration of the photographying spark from $\frac{1}{3000000}$th of a second to $\frac{1}{11000000}$th, and that he hoped to bring it down to $\frac{1}{20000000}$th. This result has been attained by merely shortening the Leyden jar circuit and substituting copper strip for copper wire, thus diminishing the inductance.

Francis Hauksbee's "Physico-Mechanical Experiments" is an interesting old book, "printed by R. Brugis for the Author, and Sold only at his House in Wine Office-court, in Fleet-street, 1709," and contains "An Account of several Surprising *Phenomena* touching *Light* and *Electricity*, Producible on the *Attrition* of Bodies, with many other Remarkable Appearances not before observ'd." Hauksbee was a Fellow, Curator of Experiments, and Assistant Secretary to the Royal Society; he greatly improved the experimental air-pump, which was then a very handsome piece of carved furniture, and he appears to have been the first to use glass in frictional electric machines.

Hauksbee made a number of experiments on the elasticity of air. More than once he seems to have thought that he had succeeded in giving a permanent set to the "spring of air." In one of these researches, intituled "An Experiment about disturbing the Spring of Air," he arrives at the conclusion "That the Springs of Air may be so disturbed by violent Impulses or Strong Compressions as to require considerable time to recover their Natural Tone and Temper and Compleat Restitution." On another occasion he compressed air in a flask to about five or six atmospheres, and "this Air continued in that state of violent condensation" for more than four months, when it was found that, in consequence of the "intemperate heat of the weather," the cement failed "to resist the Efforts of the mighty Spring of the inclos'd Air." Something went wrong with the mercury gauge, which remained at $\frac{1}{4}$ inch after the vessel was opened; but he concludes that "the injur'd Springs could not recover themselves," and "that their long detention in that violent state must needs have made them unable to unwind themselves so far as was necessary to their own Discharge." Hauksbee then asks "What kind of Liquid would so many Atmospheres of condens'd unelastic Air compose? Would not Terrestrial Animals be suffocated in it, as they would be in Water or other Fluids?" and after two other questions, "Is it impossible that Air by this means should become a Visible, Palpable Fluid; and be Subject to some of the same managements that other Fluids are?" It has been reserved for Prof. Dewar, 183 years later, to hand to Lord Kelvin at the Royal Institution on Friday last a wineglass of this very Visible, Palpable Fluid.

The short space of seventy minutes gave barely time for Prof. Dewar's experiments, and, as in Mr. Tesla's lecture, there were many points about which explanations were greatly needed. It seemed indeed as though Hauksbee's idea had been carried out to the letter, and in the liquid, at first boiling violently, but soon coming to gentle effervescence and finally clearing, the air appeared truly to have suffered a permanent set. Many tons on the square inch at ordinary temperatures would not have retained the air in a liquid form; and yet there it lay in an open glass. The explanation is that a liquid cannot turn into gas without absorbing heat. While first bubbling briskly, it was absorbing the heat of the vessel into which it had been poured, and when this had been thoroughly chilled there was nothing but the surrounding air from which to draw further supplies of heat; and this surrounding air consisted, of course, of the just liberated gas at the boiling temperature of nearly $-200°C$. The radiation from the audience was no doubt the main source of heat, and this was too feeble to keep the liquid boiling, so it had perforce to evaporate moderately.

The "intemperate heat of the weather" and "hot state of the Ambient Medium," which brought Hauksbee's experiment to a close, interfered greatly with the preparations for the experiments on Friday evening. At the last moment supplies of ice had to be borrowed from the neighbouring clubs to assist in cooling the apparatus. The liquefaction of oxygen and of atmospheric air was brought about, we understand, not by a combination of pressure and cold, as in the researches of Pictet and Cailletet, but by reduction of temperature alone. The gathering up of the liquid oxygen upon the pole-pieces of Faraday's great magnet was a notable experiment that will long be remembered by all those who saw it.

The remarkable fact demonstrated at Prof. Dewar's lecture on liquid oxygen, that air is liquefied without change of composition, is deserving of a little closer attention than was

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possible in the single hour allotted to a Friday evening discourse at the Royal Institution. Nitrogen, although boiling at a temperature 10° C. lower than oxygen, is liquefied together with it at the same temperature, because the liquefaction is effected in an atmosphere in which the pressure of the nitrogen exceeds that of the oxygen—viz., ordinary air. It was also stated, and proved by direct experiment, that the liquefied air became fractionated by spontaneous evaporation, the nitrogen vaporising and leaving the oxygen. But it is difficult to understand why that which held good for the process of liquefaction should not do so for that of gasification. Liquid air gasifying in free contact with the atmosphere would do so under a pressure of nitrogen about four times that of the oxygen, and the vaporisation of the former would be correspondingly retarded, just as its liquefaction was previously aided. According to this view, therefore, liquid air should evaporate under ordinary atmospheric pressure without undergoing fractionation. The matter certainly stands in need of elucidation; but, unfortunately, it is not given to most experimenters to deal with liquid oxygen and nitrogen by the litre.

Prof. Dewar mentioned in his peroration that the resistance of micro-organisms and seeds to intense cold went to support the suggestion of Lord Kelvin, that life might have entered this world on the back of a meteorite, the difficulty arising from the low temperature of space being thus overcome. A life-germ capable of such transmission would have, however, to endure extremes of temperature at both ends of the scale, as the temperature of a meteorite falling through an atmosphere of ordinary tenuity is raised to a point at which all life, as we know it, ceases. One would have to postulate a planet devoid of atmosphere to avoid the destructive distillation of a celestial visitant of this description.

Good old Francis Bacon would have thoroughly enjoyed Prof. Dewar's lecture. "It seemeth," he writes, in the "Sylva Sylvarum," on "Experiments Solitary touching the Version and Transmutation of Air into Water," "that there be these ways (inlikelihood) of *Version of Vapours* on *Air*, into *Water* and *Moisture*. The first is *Cold*, which doth manifestly Condense; as we see in the *Contracting of the Air* in the *Weather-glass*; whereby it is a degree nearer to *Water* . . . And the experiment of turning *Water* into *Ice* by Snow, Nitre, and Salt would be transferred to the turning of *Air* into *Water*. The second way is by *Compression*. . . . But this is like to do no great effect; except it be upon Vapors, and gross *Air*, that are very near in Degree to Water." Was Bacon in this "experiment," which appears between "Experiment Solitary touching the Venemous quality of Man's Flesh" and "Experiment Solitary touching the *Helps* towards the *Beauty* and *good Features of Persons*," nearer the mark, just a century earlier, with his wild speculations, than was Hauksbee with his leaky gauge? Are there any of us to-day so far ahead of our times? We may smile at Bacon and Hauksbee, but those men could think straight at times.

A most commendable feature in the construction of the galvanometers which were shown at the last meeting of the Physical Society was the mechanical arrangement of the moving parts in a tube, which can be easily detached from the heavier and more bulky part which constitutes the body of the instrument. We do not know whether this system first came into general use with the Evershed voltmeters and ammeters; but it has now become a most important feature, not only in economy of manufacture but in affording the utmost facility for adjustment and repair.

In the important Paper by Prof. Ayrton, Dr. Sumpner, and Mr. Mather on "Galvanometers," in 1890, the system of "scale divisions" in use at the Central Institution was explained. It was, we believe, as accidental as the adoption of the narrow gauge by Stephenson, and consisted of millimetre divisions at two metres distance, or half millimetres at a metre, these being the scales and distances which happen to have been in common use at the laboratories of that Institution. But it can hardly be expected that ignorant outsiders who have not had the privilege of passing through the classes in those laboratories can remember exactly what is meant by scale divisions; and we thoroughly agree with Prof. S. P. Thompson's suggestion that angular measure or tangents should be adopted; especially in attempts to compare different instruments by "figures of merit." One Central Institution scale division means an angular deflection, the sine or tangent of which is 0·0005, or 1 minute 43 seconds of arc. One degree would be equal to 34·9 of these divisions.

The magnetic and diamagnetic properties of miscellaneous non-metallic substances are well known by the experiments of Faraday, but the forces are as a rule so feeble that they are neither useful nor detrimental in practical work. At the Physical Society last week it was pointed out that with the powerful field and delicate construction of the modern d'Arsonval galvanometer, silk, paraffin, and copper exhibited sufficiently distinct magnetic properties to give rise to difficulties in the use of these instruments; ebonite also was found to be distinctly magnetic, or to have what was called a magnetic polish.

It has been thought that the diamagnetic property of copper has been observed in some dynamos as an apparent increase of the air gap, but the effect was probably due to armature reactions. We have searched through more than a dozen books for the value of the permeability of copper, and as a last resort looked at J. E. H. Gordon's "Physical Treatise on Electricity and Magnetism." Faraday's list including gum arabic, fresh beef, apple, and bread was given there *in extenso*, and the section closes with the following remarkable passage: "The strength of the pole of an electro-magnet having an iron core may be as much as from 32 to 45 times the magnetising force, while with a bismuth core it would only be about $-\frac{1}{4000}$ of it." In the absence of more accurately expressed information, a variety of false conclusions might be drawn from this. Maxwell put it, "the ratio of the magnetisation to the magnetic force which produces it is exceedingly small, being only about $-\frac{1}{4000}$ in the case of bismuth." To-day we should say that κ, the susceptibility of bismuth, is $-\frac{1}{4000}$, or that μ, the permeability, is, according to Ewing, 0·99882.

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In a recent number of the *Transactions* of the Reale Accademia dei Lincei, Dr. Angelo Bauti describes experiments which he has made on the magnetisation of nickel under the influence of certain mechanical stresses, with special reference to the remarkable discovery first made by Nagaoka, that a nickel wire, when suspended in a steady magnetic field and subjected to longitudinal pull, has its magnetic polarity reversed when one end of it is twisted back and forth, the other end being held fixed. The end, which is a north pole when the twist is towards one side, becomes a south pole when the twist is to the other side; and this reversal of polarity occurs in every twisting, although the magnetic field continues to act in one direction.

Dr. Bauti's observations confirm the earlier ones of Nagaoka, and show that the reversal of effect shown by the magnetometer is due to a genuine reversal of magnetisation, which affects the whole mass of the wire. With a sufficient amount of torsion he finds that the phenomenon of reversal of polarity occurs even when there is no longitudinal pull—a conclusion which forms the chief novelty in his results. From this, taken in conjunction with Ewing's experiments on the effects of simple pull in nickel (which showed no reversal of polarity when the wire was alternately loaded and unloaded), Dr. Bauti concludes that torsion is the necessary and sufficient condition to produce the phenomenon of inversion of polarity; longitudinal pull, while it accelerates the action, being neither necessary nor sufficient in itself to produce it.

Following the now common custom of the electrical press, *L'Industrie Electrique* devotes its issue of June 10th to central-station matters. Amongst other things it publishes a lengthy list of French provincial and colonial electric lighting stations, together with a map showing their location. According to this list there are over 250 stations actually in existence or about to come into existence; but as more than three quarters of them are of less than 100 horse-power and many are of only 10 or 20 horse-power, this formidable total is scarcely a trustworthy criterion of electrical progress in France. Perhaps the most noticeable features of central-station enterprise across the channel are the great utilisation of water-power, the prevalence of overhead wires, and the marked preference for continuous currents. In some 40 per cent. of the instances where particulars as to the source of power are given, water-power alone is used, and out of 242 cases distribution is effected by alternate currents in 204, and by overhead wires in 224; evidently there is no French equivalent to the Board of Trade.

The Imperial Institute having arrived at a sufficiently advanced stage to invite inspection, and to provide accommodation for a preliminary luncheon on Saturday next, a pamphlet has been published containing a full description of the building, and an attempt to explain its mission. The Colonial Office and the Royal Colonial Institute will no doubt continue to exercise their functions; but as nobody seems to have a clear idea of what is going to be done at the Imperial Institute, we venture to suggest that the magnificent hall and corridors could be used with great advantage for the conversazioni of scientific and other societies.

Prof. Helmholtz.—The Académie des Sciences has elected Prof. Helmholtz a foreign associate, in the place of the late Emperor of Brazil.

Denby v. Scott and Mountain (Limited).—In the Outer House of Session on Wednesday, judgment was given in this appeal for the defendants.

The Azores Cable.—The contract concluded between the Portuguese Government and a French company for laying a cable to the Azores was signed on Saturday last.

Bremen.—The Bremen Street Railway Company's electrical line was officially opened on the 28th ult. This line is the first in Germany operated on the overhead trolley system.

Personal.—Mr. J. Harrhy, local manager of the Eastern and South African Telegraph Company at Port Nolloth, is leaving the coast, owing to that station being disconnected by cable.

Electrical Communications with Lightships.—The Government are about to carry out experiments on the connection of the lightships on the Goodwin Sands by telegraph with the shore at Deal.

Blackburn.—In view of the Blackburn Electric Lighting Order the local tramway company have applied to the Corporation to know whether they would be prepared to supply them with electricity.

Animal Electricity.—The Aldini Medal for Animal Electricity has been awarded to Dr. A. Waller, Lecturer on Physiology, St. Mary's Hospital Medical School, by the Bologna Academy of Sciences.

Electrical Bills in Parliament.—On Monday last the Liverpool Overhead Railway Bill, the Baker-street and Waterloo Railway Bill, and the Great Northern and City Railway Bill were read a third time.

Cable Restorations and Repairs:—

	Date of Restoration.
Repairs.—Mossamedes-Benguella	June 13th.
	Date of Interruption.
Interruptions.—Bissao-Bolama.....	April 23rd.

The American Philosophical Society.—At a meeting of the American Philosophical Society, Philadelphia, on May 20th, it was decided that the 150th anniversary of the foundation of the society should be celebrated in 1893, and a committee was appointed to make the necessary arrangements.

Royal Institution.—At the general monthly meeting of this Institution on Monday last, the special thanks of the members were returned for the following donations:—Mr. Bloomfield Moore, £80; Sir David Salomons, Bart., £50; Mr. Charles Hawksley, £50; for carrying on investigations on liquid oxygen.

The Western and Brazilian Telegraph Company.—This Company has received telegraphic advices of the successful laying of the duplicate cable between Rio Janeiro and the River Plate, thus completing the direct duplicated system of their telegraphs between this country, Brazil, Uruguay, and the Argentine Republic.

Obituary.—Mr. James Radcliffe, telegraph superintendent to the Great Northern Railway Company, died at Retford on the 2nd inst., after a few days' illness. Mr. Radcliffe was born in 1828, and entered the service of the Electric Telegraph Company in 1848 at Manchester. In 1870 he became telegraph superintendent to the Great Northern Railway Company, remaining in that capacity until his death.

Lightning.—On Friday last Mr. H. C. L. Lovett, an undergraduate of Christ's College, Cambridge, was struck dead by lightning. On Sunday no fewer than three cases of churches being struck by lightning occurred in Spain. At Melias, in the province of Orense, the parish church was struck, and 10 persons were killed on the spot, while 28 were injured. At about the same time another church, at Mucientes, in Valladolid, experienced a similar visitation, five people being killed and several injured. The famous cathedral at Burgos was likewise struck by lightning. This cathedral is unprovided with a lightning conductor.

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Royal Society.—Amongst the Papers down for reading yesterday before the Royal Society were the following:—Lord Armstrong, F.R.S., "On a Multiple Induction Coil Machine and its Results;" the late Prof. J. Thomson, F.R.S., "On the Beams of Light seen with Partially Closed Eyelids;" J. Brown, "Voltaic Cells with Fused Electrolytes;" J. B. Peace, "On the Potential Difference required to produce a Spark between two Parallel Plates in Air at Different Pressures;" F. Lydall and A. W. S. Pocklington, "Magnetic Properties of Pure Iron;" and T. Andrews, F.R.S., "Electro-chemical Effects on Magnetising Iron—Part IV."

The Atomic Weight of Oxygen.—Mr. R. Lehfeldt writes as follows to *Nature*:—"I notice that Lord Rayleigh gives the following summary of results on the atomic weight of oxygen:—Dumas, 1842, 15·96; Regnault, 1845, 15·96; Rayleigh, 1889, 15·89; Rayleigh, 1892, 15·882, showing the remarkable fact that the atomic weight has been steadily decreasing for the last 50 years. I would suggest, as the explanation of this, that the increased population of the world, together with the great consumption of coal, have caused great wear and tear of these atoms, so that they are now mostly deficient in weight. It would seem, in fact, desirable that a Congress of chemists should be called to consider the question of providing for the renovation of the oxygen supply, and issuing trustworthy atoms of the standard weight, 16, as sealed patterns."

The Electric Discharge.—At a recent meeting of the Cambridge Philosophical Society, Prof. J. J. Thomson read a Paper on the pressure at which the electric strength of a gas is a minimum. Prof. Thomson showed that when no electrodes were present the discharge passed through air at a pressure somewhat less than that due to 1/250mm. of mercury; the discharge passed with greater ease than it did at either a higher or a lower pressure. Mr. Peace had lately shown that when electrodes were used the critical pressure might be as high as that due to 250mm. of mercury, so that as the spark length was altered the critical pressure might range from 250mm. to 1/250 of a mm. This involved the possession by a gas conveying the discharge of a structure much coarser than any recognised by the kinetic theory of gases. Prof. Thomson suggested a theory of such a structure, and showed that the theory would account for the influence of spark-length and pressure on the potential difference required to produce discharge.

Copper.—A correspondent of the *Economist* points out in the issue of that journal of June 11th that the arrangement with regard to the restriction of the output of copper, referred to in our last issue, only binds the American and European producers, and that there is nothing to prevent other countries increasing their shipments. Already the shipments from Chili, in consequence of the close of the revolution, are considerably in excess of those of last year, and promise to increase still further. With regard to the consumption of copper, it is pointed out that from the figures of Messrs. H. R. Merton and Co. the deliveries in England and France during the 12 months (June 1, 1891, to May 31, 1892) were 112,035 tons as against 139,075 tons in the corresponding period of 1890, and 145,796 tons in 1889-90. This would seem to indicate that the lower prices which have recently obtained have been consequent on reduced consumption. The correspondent of the *Economist* is of opinion that it is very probable that stocks have increased by several thousand tons during the past year.

Boiler Test.—Mr. Bryan Donkin, jun., and Prof. Kennedy in the course of their standardised steam-boiler experiments, tested a new portable locomotive type of boiler with a steel shell, by Messrs. Marshall and Co. It was working without any brickwork protection, and was not housed in any way. The boiler got up 70lb. of steam in 39½ minutes, starting all cold. The boiler was lagged in the usual way, and the steam, which was kept at about 61lb. during the test, was used to supply a compound steam-engine. The general dimensions of the boiler were as follows:—Fire-box inside, 3ft. 3in. by 2ft. 11in., and 3ft. 1in. high from the fire-bars; diameter of barrel, 3ft. 7in., and 7ft. 9in. long, with 50 tubes 2½in. in diameter. The total heating surface of the boiler was 316 square feet. In the course of the eight hours' trial, the furnace burnt 960lb. of coal; and the equivalent evaporation per pound of coal from and at 212°. Fahr. was 10·78lb. of water, corresponding to 11·25lb. per pound of pure and dry coal. According to the balance sheet of the boiler, 69·8 per cent. of the total heat went to heating and evaporating the water; 18 per cent. is accounted for in the furnace gases; and 5·7 per cent. was lost by radiation—leaving 5·2 per cent. unaccounted for.

Electric Railway Accidents.—On Friday afternoon last a Mr. Alfred Edward Stewart was crushed under a carriage on the City and South London Electric Railway. At the inquest it transpired that a guard came up and asked the deceased and a friend whether they would like to see the engine at work. They replied in the affirmative. The guard having opened the door, the deceased stepped on to the engine and disappeared down the opening between the engine and the carriage. The space between the engine and carriage was about 7in. The width of the carriage platform of the first carriage was 3ft. The train was in motion at the time, and was about 100 yards from the Elephant and Castle Station. A juryman remarked that he had often been invited by the guards on the City and South London Electric Railway to view the engine. The jury returned a verdict of "death by misadventure," and severely censured the guard.—A cablegram from New York states that an accident resulting in three deaths occurred on the Atlantic and Chattahoochie River Electric Railroad, owing to a derailment.—Another electric railroad accident is also reported from Wheeling, Western Virginia, owing to an electric car coming into collision with a crowded passenger train. The car was completely demolished, and three of the occupants killed.

Prize for Researches in Physics.—For the year 1894 a prize of 2,000fr. is offered by "Schnyder von Wartensee's Foundation," for the solution of the following problems:—"As the numbers which represent the atomic heats of the elements still show very considerable divergences, the researches conducted by Prof. H. F. Weber on boron, silex, and carbon, regarding the dependence of the specific heats upon the temperature, are to be extended to several other elements, prepared as pure as possible, and also to combinations or alloys of them. Further, the densities and the thermic coefficients of expansion of the substances investigated are to be ascertained as carefully as possible." The treatises handed in by competitors for the prizes may be in German, French, or English, and must be sent in by September 30, 1894, at the latest. The work to which the first prize is awarded is to be the property of the Foundation, and arrangements will be made with the author regarding its publication. Every treatise sent in must have a motto on the title-page, and be accompanied with a sealed envelope bearing the same motto outside and containing the author's name. The treatises are to be addressed "An das Praesidium des Conventes der Stadtbibliothek Zürich" (betreffend Preisaufgabe der Stiftung von Schnyder von Wartensee für das Jahr 1894)."

Magnetic Leakage in Dynamos.—A great deal of energy that might be better spent, says *Industries*, is wasted over the discussion of the waste field in dynamos. In spite of the spread of knowledge of magnetic circuits, there still seems to be a fallacy lurking in the subject. Many writers still seem to think that a certain number of ampere turns on the field must produce a corresponding total number of lines of induction, and that if a large proportion of these pass round the armature there will be fewer left available to go through. This is a complete misunderstanding of the question. The only effect of increasing the leakage is to produce more lines. They do not cost anything, and do not matter, except for one thing. They decrease the permeability of the field magnets, so they demand slightly more iron in the fields. The only bearing leakage has on dynamo design is in altering the permeability of the fields. A compound dynamo, for instance, should not have its field permeability too high at no load, or its pressure will be unstable; on the other hand, at full load the permeability should not be so reduced that too much excitation is needed to give the desired pressure. Various methods of constructing ironclad dynamos still appear from time to time. Another form of the same fallacy consists in winding the field excitation round the armature to ensure that all the lines shall go through the armature. This results in ruining the ventilation to gain nothing.

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NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 144.*)

12. Removal of Fault.—Before the fault comes inboard we may as well look at what is going on in the testing-room. Ever since the ship began to pick up cable in the direction of the fault, incessant work has been going on in this part of the ship, involving great skill and judgment, and not unfrequently some amount of anxiety. The nature of the work depends upon the kind of fault to be removed, and whether communication can be kept up with the shore during picking up. If the fault is one of high resistance, as is most often the case in these days, communication can be kept up with the shore, and from time to time, as picking up goes on, the superintendent of the station on shore may be requested to test the line while the ship frees or earths the end on board. The results so obtained are communicated to the ship, and, when taken together with those obtained on board, form a valuable means of arriving at the true position of the fault. An earth overlap would be tried at intervals, and probably a Mance from both ends. Kingsford's modification of the Blavier would also be tried, and the rate of polarisation carefully watched. If, on the other hand, it were not possible to communicate with the shore, as in the case of a low-resistance fault or total break, the ship would rely chiefly on the Kennelly test, with various strengths of current. A brief reference to these tests was made in the introductory remarks to this series in issue of February 12th, page 379; but as it is proposed to enter fully into this subject in a later chapter, we need not at the present stage do more than name the methods most likely to be used.

The question is often asked, "How near can you ascertain the position of a fault in a cable?" Well, sometimes as near as to a tenth of a mile, and at other times not within 15 or 20 miles. Perhaps the most average limits, however, fall somewhere about within five miles. These limits depend largely upon the nature of the fault and whether there are more faults than one in a given cable. The easiest fault to localise is a fracture in which the broken end is insulated, caused by the percha or rubber stretching and closing over it. A total break with a good earth connection probably comes next. Then there are faults of varied sizes, making partial earth; those which are smallest, and therefore of highest resistance, being the most difficult to localise. The greater part of a cable-ship's work on repairs now-a-days is in removing the latter class of faults of high resistance; for while the number of cables has gone on increasing by the laying of duplicate and triplicate lines, their manufacture has been so far improved, and the protection against the teredo so effective by the introduction of brass-taped cores, that faults are of less frequent occurrence than in former years, and are consequently removed upon their first appearance. Some 12 or 15 years ago, before the introduction of these cables, and in the days when there was one ship operating over a given mileage where now there are two—it was a common thing for faults to be so numerous that the ship had only time to deal with those which either totally interrupted traffic or through which messages were transmitted with great difficulty. Especially in the Straits, Java, and China Seas, the happy hunting grounds of the teredo, cables used to be in a chronic state of weak insulation, with, perhaps, bad faults on three or four at one time. In those days many laborious hours were spent in deciphering Morse signals on the recorder slip, shattered by kicks from the fault, and only saved from dying down to a straight line by frequent applications of copper current. Such faults could be easily broken down to from 10 to 40 ohms with 50 cells, and it was deemed a high resistance fault that could not be got down to a hundred or two. All this is changed to-day, telegraphic communication from one end of the world to the other by submarine cables being more reliable and constantly maintained; and faults, dealt with on first causing a lowering of the insulation, are of enormously high resistance, varying from 5,000 to 100,000 ohms or more. The higher the resistance of the fault the longer the charge current lasts, and the longer the testing current must be kept on before a reading can be taken. Further, as the fault polarises rapidly, it is very difficult to get a satisfactory test.

But we must take a turn in the testing-room, and make ourselves acquainted with the apparatus used. The testing-room on board most modern ships is situated on the upper deck, and generally about amidships. In climes under

> "Those blazing suns that dart a downward ray,
> And fiercely shed intolerable day,"

the door is kept wide open on the hook, and a hanging curtain takes its place, allowing air to play in, while the light admitted can be modulated at will. The testing table is arranged with all the necessary instruments, and the insulation of all the various pieces is very carefully ensured. The table is covered with sheet gutta-percha, and all the insulated wire used in the connections is fixed in position with small gutta-percha straps or staples. Besides the testing table there is usually a folding writing table and chair, also a nest of drawers for keeping small tools, spare jointing materials, galvanometer mirrors and suspensions, &c. The batteries, which may amount to two or three hundred cells, are all ranged in racks underneath the testing table, and the connections brought to commutators, by which the battery power can be easily changed as required. There is also a library and a comfortable lounge along one side of the room; this sanctum of the electrician being generally a cosy little place, where are spent some of the many hours passed at sea while steaming from one position to another. In bad weather it is a welcome retreat, and, where you can, reclining

> "With sidelong eye look out upon the scene,"

though it may be in no such satisfied frame of mind as Wordsworth's dreaming man.

It will be understood that on starting the coiling of cable picked up, the end was left sticking up at the side of the tank so as to be accessible for connecting on an insulated leading wire to the testing-room. This insulated wire remains so connected until the first cut takes place, when it is shifted on to the new end. In the testing-room the end of this wire is connected to the testing terminal during the ship's tests, or is shifted over to a terminal on the speaking connections when it is desired to communicate with the shore. Also in the periods of time during which it is arranged for the shore to test, the end is either freed or earthed by the ship as required.

A set of testing and speaking connections, such as fitted in the testing-room of a repairing steamer, is shown in Fig. 38, the testing galvanometer, speaking mirror, lamps, and scales being shown in elevation, and the testing apparatus and connecting wires in plan. The apparatus and arrangement of connections vary somewhat in different ships, but are generally arranged in such a manner that by simply changing one or two plugs the cable can be tested by bridge or deflection methods. The galvanometer used on all ships is the marine galvanometer of Lord Kelvin, which, enclosed in a thick soft-iron case, is perfectly screened from external magnetic influences occasioned by the motion of the iron-built ship. In the set of connections here shown, which were so arranged on board the cable-ship "Agnes," the cable is connected to the terminal S for speaking to the shore, and to the terminal X for testing, the commutator plugs P P and the plug B being put in for bridge test, and the plug D being put in (the others being removed) for deflection test. In this set the bridge ratios of 10 to 10,000 ohms are in a separate box, and the adjustable resistance is made up in the dial form, which has the advantage of using only one plug for each dial, and does not, therefore, depend on the contacts made by other plugs. The earth terminal in the testing-room is usually connected to the sheathing wires of the cable under test. The deflection test is used on first cutting the cable after grappling, to rapidly show which end has faulty insulation, and is also used continuously during paying out to show that the cable remains perfect, and to detect, should such an untoward event happen, the paying out of a faulty length. The same connections may also be used when measuring the insulation by fall of charge or seeing what amount of capacity there is in

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the length of cable from ship to shore. From the deflection test connections it will be seen that it is only a matter of a few seconds to change over on to the bridge connections by the plugs. The bridge is used for all practical fault localisation tests, and, with the exception of the Mance test, the balance is obtained to the false zero caused by the polarisation of the fault.

The momentary current of charge referred to above is due to the fact that the cable from the ship to the fault is like a big condenser, and takes a considerable static charge when its conductor is put in connection with one pole of the testing battery—the other pole being to earth. The cable becomes statically charged—that is, considering the two concentric metallic conductors, the internal copper conductor and the outer metallic sheath, there exists between these two surfaces, along the whole length of the cable up to the fault, a charge of a certain quantity of electricity through the insulating material. The rush of current due to this charge is only momentary, but of great strength—that is, a sensitive galvanometer would have to be heavily shunted to keep the throw on the scale at all. But, except when measuring the capacity of the cable, this violent kick or throw is never wanted, and in the various bridge tests it is a decided bugbear. The short-circuit key connected to the galvanometer terminals, as shown in the illustration, is specially provided to short-circuit the galvanometer on the first application of the testing current and prevent this rush of current passing through it. Now small faults polarise so quickly that the testing current cannot be kept on for a longer time than will allow the charge current to pass, and the short-circuit key on the galvanometer is therefore opened after a sufficient time is judged to have elapsed. But it is a difficult matter to judge this time; should it be opened too soon the result on the bridge will be too low, owing to the charging current, while if too late the result will be too high, owing to polarisation of the fault.

Further, the same cause interferes with the correct reading of the false zero. The false zero is the deflection of the galvanometer caused by the polarisation current from the fault itself, and what is wanted is to find the strength of this current which acted during the time the testing current lasted. Now, as the electromotive force of polarisation falls after the battery current ceases, it is clear that the sooner it is observed after the battery key is released the better. In releasing the testing-key the back contact completes the circuit from the conductor of the cable through the galvanometer to the sheathing, which permits the polarising current to flow; but, unfortunately, at the same time the static charge is now given up or discharged, since the two charged surfaces—the conductor and the sheathing—are now united through the instrument. The galvanometer must therefore be kept short-circuited, after the cessation of the testing current, for a sufficient time to allow this discharge to be completely dissipated, or else it will make the false zero falser still. The exact time, which varies from about five or six seconds on lines up to 400 miles, and up to ten or fifteen seconds on lines up to 1,000 miles, is not easy to judge when a fault is under test.

With a single fault making partial earth it generally happens that when tested from the ship at close quarters it can be opened out more with the zinc current and its resistance reduced, so leading to a more definite assigning of its position. Suppose, for instance, that after trying a number of different tests from the moment the ship starts picking-up the fault is estimated to be 3½ miles off. Orders will be given to cut at 4 miles, and when the rotometer shows this length hauled in the cable is cut, generally in tank, and the new end connected up to the testing-room. Tests now may show the fault to be still further away, and orders are given to continue picking up. Tests are now applied again, and this time it is estimated that another half-mile will bring in the fault. The cable is accordingly cut again, but the fault may be still further off. By a test on this fresh end the fault is probably better got at, and, certain that the fault cannot be far from the ship, the electrician gives orders to cut after another mile has come in. This being done, and the new end being connected to the testing-room, he has the satisfaction to find that his low readings have disappeared, and the cable now hanging to the ship is electrically perfect. The fault is, therefore, contained somewhere in the last piece coiled in tank, which is labelled, and shortly afterwards treated to a loop test, spotted, examined, and reported on. Each time the cable is cut the drum is heavily braked and the engine stopped.

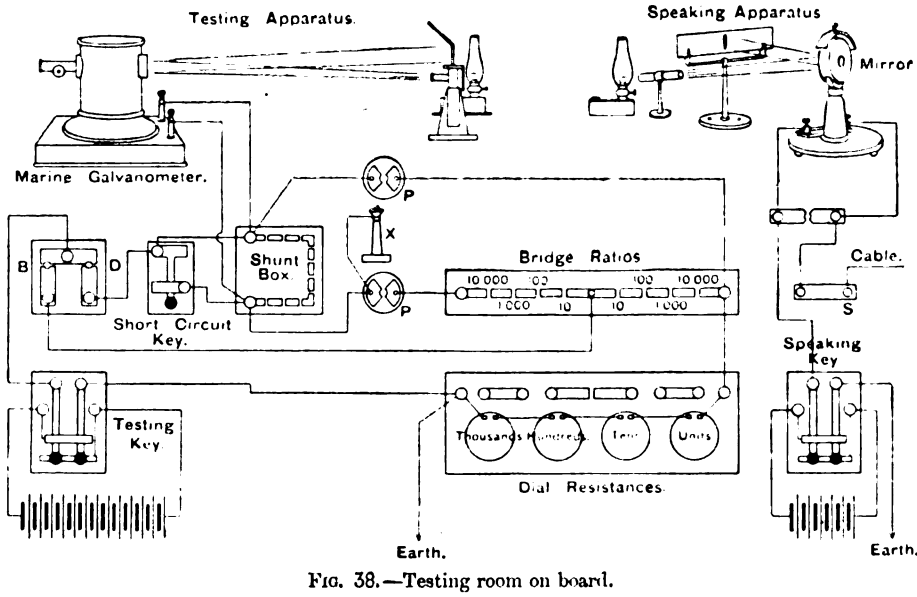

FIG. 38.—Testing room on board.

Very varied successes attend this work of removing faults. Sometimes the first position is close to the fault, at other times it appears close but is really not so; and after testing and cutting, say, five or six times over a length perhaps of eight or ten miles, the fault is at last got inboard. In other cases of less frequent occurrence it may be estimated after one cut has been made at, say, two miles, that the fault is much further off, say, 15 miles. In that case the cable end is buoyed and the ship runs on about 16 miles further and grapples. Having got cable, it is cut and tested, and the good end buoyed. Say the fault is found to lie towards the second buoy. After cutting at three miles, say, the fault is found to be inboard. A good piece is then spliced on and paid out up to third buoy, where the end is spliced on to the end on buoy. Finally, the ship runs back the 16 miles to second buoy, splices on a piece to this end and pays out to first buoy, where the final splice is made. In the case of a break, of course, cable is picked up till the broken end comes on board, and the ship then steams about a mile and a-half further on, lowers grapnel, and after hooking cable, cuts it, buoys the good end and picks up to other end of break. She then runs back to the last buoy, splices on

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and pays out to the first buoy, where the final splice is made. When, however, there is any such wide difference between the estimated and actual position of the fault as in the foregoing example it is in most cases discovered by the ship upon first cutting in. Before proceeding to buoy or pick up, and while the two ends are on board, several tests will be tried. If the electrician's first test places the fault considerably further on or further back, say, 20 miles, it is a matter of great importance to confirm this by other tests, and if there is a duplicate cable in good condition he will request the end with whom he can communicate to take a loop test. This end accordingly advises the other end to loop his cables. Whereupon the ship joins the two ends, or, as it is called, "puts D F" on board for a predetermined time, say, five minutes. This result may again be confirmed by the ship taking a loop test with the two shore stations looped through. Supposing that these tests all confirm the first and place the position of fault considerably further away, the ship, after advising the shore, permanently splices the cable together again where it was cut, throws the bight overboard and runs on to the newly-estimated position, where she grapples and cuts in as before.

When it is known on board that the fault is removed, the cable end hanging to the ship is at once stoppered, and the end of a sufficient length of good cable (in this case about five or six miles) is got up ready for splicing. The jointer and his mate are on the scene, and commence preparations on the new end to be joined on. The seaward end is not at liberty for a few minutes, as now communication is restored with this end there are several service messages to be sent and received. After the test proving the insulation perfect, the ship calls up the shore and sends a message to this effect to headquarters: "Fault removed (say) 490 miles from ——, now join up and pay out." Also a similar message to the superintendent on shore: "Fault removed, now join up and pay out, free one hour, then look out." The cable is always freed by the shore for one hour during the making of a splice, to allow for tests during and after splice is made. We will now turn our attention to the making of the cable joint and splice.

[**Erratum.**—On page 143 the fourth line of the second column should read "one-twelfth additional weight."]

(To be continued.)

"THE EARTH" ON ELECTRIC RAILWAY CIRCUITS.

In an article in the *Western Electrician* of April 16, Mr. Charles Proteus Steinmetz discusses the question, "Which Terminal shall we Ground in Electric Railway Circuits?" The matter is one of some importance to engineers; and in view of the prognostications in the recent Lane Fox case, as to the difficulties which would arise if an earth return were used for electric lighting circuits, it is not without interest to learn what has actually occurred in practice on electric railway circuits. We therefore reproduce some extracts from Mr. Steinmetz's article:—

In most electric railway systems the circuit is grounded by using the rails as return. It is thus, indeed, not a true earth return circuit, as employed on telegraph lines, because for such large currents as employed in railway propulsion the carrying capacity of the earth is not sufficient to quickly distribute the current. Therefore, a metallic return circuit is always provided by connecting the rails with each other and with a bare underground conductor, which carries the return current, so that the earth forms only a shunt to the return circuit. But, unfortunately, the earth is not a "metallic" conductor, but is an electrolytic conductor. Therefore, for every ampere of current which passes through the ground a rigidly determined amount of chemical action must take place. Considering the large amount of current always circulating in the return wires of extensive railway systems, and the vast surface of rails and conductors exposed to the earth, we cannot wonder that practice proved rapid destruction of return wires and rail bonds by electrolytic action. It became customary, therefore, to connect the negative terminal with the return circuit and the positive terminal with the trolley line. The reasoning which led to this custom was about the following:—If an electric current passes through an electrolytic conductor at the positive terminal, oxygen is developed, which rapidly dissolves all the metals except very few, while at the negative terminal metals or hydrogen are set free, which affords a thorough protection for the negative terminal. Therefore it was thought that by connecting the return circuit to the negative terminal it would be protected against electrolytic destruction.

Suppose the positive terminal connected with the trolley line, the negative with the return wire, and let us follow the path of the current. Leaving the central station, the current flows over the trolley line through the motors to the rails, from rails to return wire, back to the station, while a shunt-current branches off from the return circuit at or near the motor, passes through the ground, and enters the return circuit again in proximity to the power-house. Consequently, the rails and the return wires at and near the motor will be positive against the earth and eaten away by electrolytic action, and near the central station rails and wires are negative against the earth and protected from destruction. Consequently a neutral zone exists where the earth potential is the same as the potential of the return circuit.

Let us connect, now, the negative terminal to the trolley line the positive to the return. Then the whole phenomenon is simply reversed, and the other half of the return circuit is endangered.

Changing the line terminals frequently would not help either, but only damage the whole system of return wires equally. Besides, a change of the line terminals meets with difficulties caused by the necessity of protecting the station against electrostatic discharges from the line; that is, against lightning. This makes it necessary to connect the series coil of the compound generator to the trolley line, so that a disruptive discharge, entering the power station from the line, finds its path obstructed by the heavy self-induction of the series coil, and is thereby forced to jump at the lightning arrester; while, in reversing now the terminals, the series coil of the generator field would be between armature and ground, and such an oscillating discharge would find a free path into the armature, and very likely, not being able to pass from the armature to the ground through the impedance afforded by the series coils, disruptive discharge would destroy the armature. So we see that there exists no possibility of protecting a grounded return circuit against electrolytic action by connecting either the one or the other dynamo terminal to the return circuit; but in either connection half the circuit is protected, while the other half is exposed to oxidation.

If the central station is provided with a large and extensive ground a slight advantage exists in favour of connecting the positive terminal to the return circuit, because in this case a part of the current enters the earth over the ground in the station, and thereby the neutral zone of zero potential is moved nearer toward the station; and if it were possible to make the ground in the station of such a low resistance that it is equal or superior to the ground afforded by the whole return circuit, which is practically hardly possible, the radius of zero potential would coincide with the limits of the power house, and the whole return circuit be protected by throwing all the destructive action upon the ground in the central station. Connecting the positive terminal to an extensive ground in the station, and interposing a suitable resistance between the return circuit and the positive terminal, would bring the return circuit below the earth potential also, and thereby protect it, indeed, by the expenditure of a certain amount of energy in the resistance.

Besides this integral circuit, local electric circuits are formed between the iron rails and the copper conductor, iron and copper forming a galvanic couple. If the positive dynamo terminal is on ground, the line current flows against this E.M.F., and at least occasionally impedes its obnoxious action, while, by grounding the negative terminal, the live current flows *with* the local currents.

Hence, neither by connecting the negative nor the positive terminal with the grounded return circuit, can protection be secured. But in regard to local currents it is more advisable to connect the positive terminal to the return circuit, which practice is also of some advantage if a separate ground in the central station is provided.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, June 24th.

PHYSICAL SOCIETY.

5 *p.m.* Papers to be read: (1.) "Breath Figures." By W. B. Croft. (2.) "The Measurement of the Internal Resistance of Cells." By E. Wythe Smith. (3.) "Units of Measurement." By Mr. Williams.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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MECHANICAL SCIENCE AT CAMBRIDGE.

There is some difference of opinion as to the distinction between scientific education and technical instruction. The practical bearing of pure science on the manufacturing and industrial arts is as evident as the grounding in science which is the foundation of sound technological training. Hitherto the distinction has been tolerably well maintained, but it seems likely to diminish and in many cases to disappear completely. It is because the foundation of engineering, and more especially of electrical engineering, is scientific, that those who are connected with these professions may be expected to take an interest in the teaching of science; but because their aims are for the most part utilitarian, and their work, so far as it is professional, is essentially commercial, there have of late been many expressions of surprise, and even sneers, at the idea that any form of knowledge may be valuable and at the same time useless; the paradox depending merely upon the meaning attached to the word "useless." Rather more than a year ago we gave a sketch of the development of the School of Engineering at Cambridge and made an appeal for the laboratory which it was then proposed to found. On that occasion (*Electrician*, vol. XXVI., p. 668) we quoted from a Report upon this subject, which gave several indications of a change in the University system. Last week we gave an abstract of a Report upon the proposed Mechanical Sciences Tripos, which described pretty clearly the arrangements which are contemplated, and the reasons for the recommendations. The University of Cambridge is officially defined as "a society of students in all and every of the liberal arts and sciences;" and the question at once arises, what are these liberal arts, and why are they so called? There may be, for all we know, a diversity of opinion here, as there is evidently a diversity of purpose; but going back to the origin of the term, we know that the *artes liberales* among the Romans were the higher

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arts which only freemen were permitted to pursue. These in the Middle Ages were known as the seven branches of learning: grammar, logic, rhetoric, arithmetic, geometry, music, and astronomy; among these may to-day be included philosophy, history, philology, and natural science, though it is only quite recently that the last has been accepted at Oxford. A liberal education is not antagonistic to technical instruction: the former enlarges and disciplines the mind and makes it master of its own powers, irrespective altogether, as the name implies, of the particular business or profession that may be afterwards followed; the latter gives a sound knowledge of the principles of a trade.

The educational value of technical instruction is accidental. No one can intelligently read the elementary chapters of Maxwell's "Theory of Heat," and parts of the writings of Huxley, Lyell, Darwin, and Tyndall, without deriving educational benefit from them on account of their literary excellence, quite apart from the subject matter. An interesting claim for the educational value of science is made by President Walker, of the Massachusetts Institute, in the last number of the "Technology Quarterly": "The sincerity of purpose and the intellectual honesty which are bred in the laboratory of chemistry and physics, stand in strong contrast with the dangerous tendencies to plausibility, sophistry, casuistry, and self-delusion which so insidiously beset the pursuits of metaphysics, dialectics, and rhetoric, according to the traditions of the schools. Much of the training given in college in my boyhood was, it is not too much to say, directed straight upon the arts which go to make the worse appear the better reason. It was always an added feather in the cap of a young disputant that he had won a debate in a cause in which he did not believe. . . . Contrast this with the moral and intellectual influence of the studies and exercises we are considering. The student of chemistry or physics would scarcely know how to defend a thesis which he did not himself believe. The only success he has hoped for has been to be right." An ingenious argument, more favourable to science than unfavourable to classics.

The reason for the establishment of a Tripos which thus ranks mechanical science with such important branches of knowledge as classics, mathematics, history, and natural science is plainly stated in the Report which we published last week. The present ordinary degree in "Mechanism and Applied Science" in which no honours are given, is "wholly inadequate for the more able students;" and "the want of such an examination deters men from coming to Cambridge who would otherwise be likely to profit by the training in science which the University offers." To this it may be answered that an able student, if he can afford the time, had far better make use of the opportunities afforded for a thorough acquaintance with natural sciences generally, or perhaps of physics in particular, by the existing Tripos. If he, and those who are at present deterred from going to Cambridge, want to learn a profession, they ought to go to the establishments which have been founded for that very purpose. It is probable that the University will suffer if it holds out baits to men who would have hitherto gone to technical colleges, and for whom the University as a university otherwise offers no attraction. The difference between pure mathematics and applied or mixed mathematics is a mere nothing compared with the difference between theoretical thermodynamics and slide-valve setting, or between the adjustments of a spectroscope and of a theodolite. The fact that the one of these is primarily an instrument for scientific research, and that the other is the tool of a surveyor, places a wide gulf between them. If the progressive party have their way, the University seems likely to attract a different class of man, who will look to the utility of all he learns, and will work with a distinctly commercial aim, perhaps under professors who take out patents! Let those who induct their pupils into trades, scientific or otherwise, foster the commercial spirit which is essential to commercial success, but, for heaven's sake, may Cambridge never merit the reproach of becoming a university of shopkeepers!

If the Tripos is really confined strictly to mechanical science as science, and not as technical instruction which is not necessarily scientific or educational, no harm will be done; but the very fact of its extreme utility and practical application will make it extremely difficult to adhere to this ideal. There will, in fact, be (according to modern paradoxy) a danger of teaching something useful. "What in the name of the Bodleian," writes Augustine Birrel, "has the general public to do with literature?" and what in the name of the Cavendish, may it be asked, have the "liberal arts and sciences" to do with most of the subjects for the "practical examination" of the proposed Tripos? Practical examinations in pure science are of course indispensable; but some of the subjects, for example, the measurement of the modulus of elasticity of materials, were set for practical examination work with a cathetometer in the Cavendish laboratory twelve years ago. The expressions "practical" and "theoretical" cannot be so easily applied to classics. Theory there may mean philology, and practice, translation and composition; or theory may be used for the study of ancient philosophy, and practice may include a course of conversational lessons in modern Greek, followed by a Cook's tour in the Peloponnese and a long vacation spent in comparative scaphology and general oryctics.

The use of a practical examination in physical science is to show whether a student is conversant with laboratory apparatus and has an intelligent appreciation of and acquaintance with the methods of experiment and measurement, and has nothing to do with the application of knowledge to some utilitarian or remunerative end. The more opportunities that are given for the study and development of pure science at Cambridge, the better for the science of this country and of this age; and physical science is not behind the other important branches of knowledge which form the subjects of the Natural Science Tripos. There is indeed room for wide expansion; for while chemistry and physiology have numerous important subdivisions, and a whole range of subjects such as mineralogy, crystallography, palæontology, are included under geology; physics, which cover mechanics, heat, sound, light, magnetism, and electricity, is the most comprehensive of them all. Nearly the whole of the really scientific subjects of the proposed Mechanical Sciences Tripos fall under the head of Mechanics as the first section of Physics. Students going in for honours in Natural Science are expected to specialise in one subject; and there seems no reason why in so wide a one as physics, special attention should not be paid to one section, and opportunity afforded by the examiners to allow a first class to be taken mainly in this important subject, together with any one other, say electricity. This would not lower the standard of the educational system; it would meet most of the arguments which have been put forward in support of what is really an Engineering Tripos; and while the present ordinary course in Mechanism and Applied Science would benefit largely by the development of the laboratory and higher classes, there would be no danger of introducing at Cambridge, under the guise of another science Tripos, an imitation of, or a competition with, the technical colleges which serve so useful and so different a purpose in other parts of the country.

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THE USE OF WATER-POWER FOR ELECTRICAL PURPOSES.

BY NORMAN F. WILSON.

(*Continued from page 146.*)

Having briefly dealt with the questions of measuring water, the efficiency of turbines and waterwheels, and the flow of water in pipes, we shall now describe a few of the more prominent types of turbines, and discuss their suitability for electrical work.

There are five different types of turbines now in the market, any one of which is greatly superior to the old-fashioned waterwheel for nearly every description of work, and is certainly so for driving dynamos. The five types are:—I., Inward flow; II., Outward flow; III., Axial flow; IV., Mixed inward and axial flow; V., Tangent.

In inward flow turbines the water is directed by guide blades against the circumference of the wheel, and leaves it at the centre. In outward flow turbines the guide passages are inside the wheel, and the water leaves at the circumference. In axial flow turbines the water enters and leaves the wheel in a direction parallel to the axis or shaft on which it revolves. In turbines of mixed flow the guide blades are outside the wheel and direct the water against its circumference as in type I.; but instead of leaving the wheel in the centre the water is turned round and leaves as in type III. In a tangent turbine there are no guide blades, the water being directed against buckets on the periphery of the wheel through a nozzle.

The chief points to be taken into consideration when choosing a turbine are:—Economy of water. Simplicity of construction. Regularity of speed and the readiness with which it can be adjusted to varying quantities of water.

Two other important considerations are, whether they can be placed above the tail water and work by suction, and their liability to be backwatered in time of flood. All the turbines we shall describe have fulfilled the first of these conditions, are of simple construction, and are not likely to get out of order.

Every turbine has a tendency to race when the load is taken off, but the design of the inward flow type renders it less liable to extreme fluctuations of speed than the outward flow because the centrifugal force of the wheel to a certain extent checks the flow of the water, whereas in the outward flow it has the reverse effect.

Types I., III., and IV. may be placed at any height not exceeding 30ft. above the tailwater level, using the fall below the wheel by suction as efficiently as if it were acting by direct pressure above. That is to say, that the pull of the column of water standing in the suction pipes below the wheel causes the water entering it to move as rapidly and with as much kinetic energy as if it had the whole fall acting by pressure.

This may be easily illustrated by the following simple experiment. Fill a glass tube three or four feet long with water, and having covered up the top end tightly with a finger, place it upright in a basin of water. The water will, of course, stand in the tube, and there will be a pull on the underside of the finger equal to the weight of the water supported. In turbines working by suction the action is precisely similar. The whole pressure of the air is on the top of the water above the wheel, whilst below there is only this pressure, less that taken to support the water in the suction tubes.

It is not usual in practice to place a turbine more than about 25 feet above the tailwater level, as it necessitates the glands being very tightly packed. There is no loss of power when a turbine of any one of these types is working by suction, provided the suction tubes are kept air tight.

When choosing a turbine this question must not be neglected, since one which can utilise part of the fall by suction is, as a rule, more convenient than one which cannot. The wheel is keyed into a horizontal shaft which has all its bearings above water, and from which the power can be transmitted by belting direct to the dynamo without any gearing.

Types I., III., and IV. are not affected by back water when the water rises in the tail race in time of flood, except in so far that they give less power on the reduced fall.

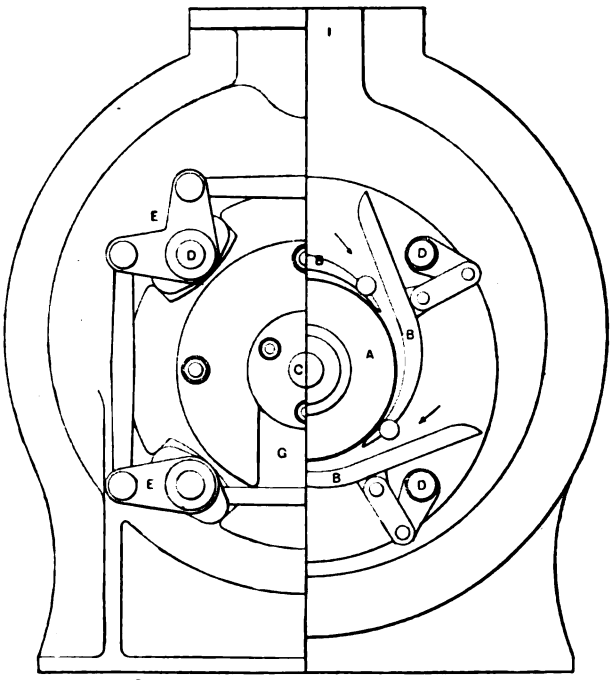

FIG. 2.—Vortex Turbine, end view, part section.

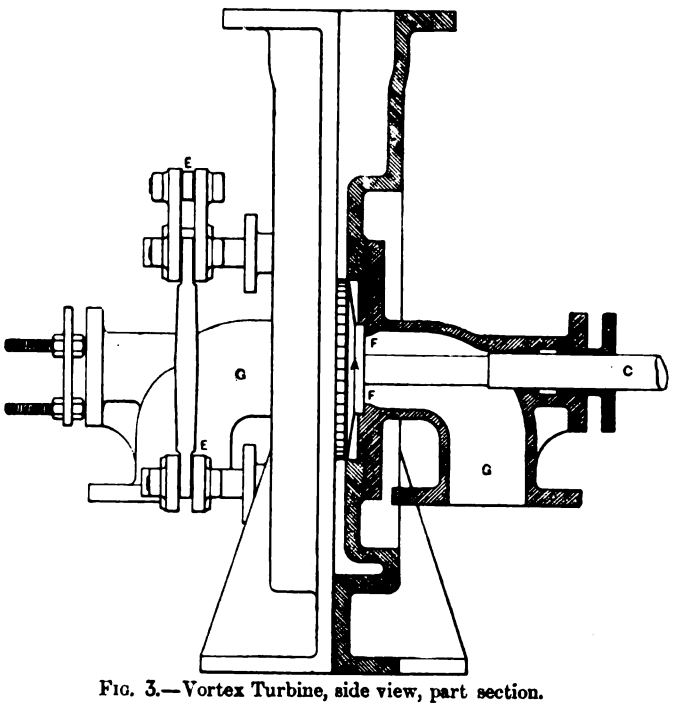

FIG. 3.—Vortex Turbine, side view, part section.

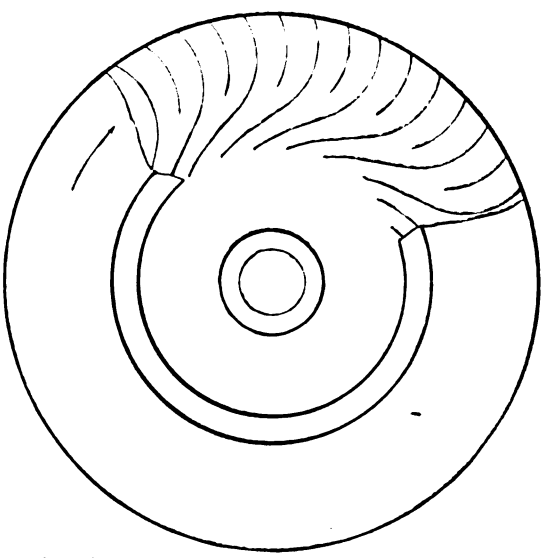

FIG. 4.—Wheel of Vortex Turbine, on larger scale.

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We shall now describe one or more well-known varieties of each type in the order enumerated above, pointing out their chief characteristics and when each type may be most suitably applied.

Inward Flow Turbines.

We shall take the vortex turbine as our example of this class as it is the first that was constructed and is much used in electrical installations.

The vortex was invented in 1851 by the late Prof. James Thomson, of Glasgow, and since that date has been placed on falls varying from 2ft. 9in. to over 500ft; it has in fact been effectively applied to almost every height of fall that is available in this country.

Figs. 2, 3, and 4 shows the general construction of this turbine very clearly. The water enters an outside chamber through the inlet I, whence it is directed by the guide blades B against the revolving wheel A. The smaller sizes of wheel are made of brass and the larger of wrought steel tenoned and rivetted together. The wheel is divided in the middle by a centre plate which is screwed or keyed into the shaft C. The water leaves the wheel by the central eye, half of it passing out at each side, through the suction pipes G G., which are provided with glands for making an airtight joint. The wheel A makes a practically watertight joint with the suction pipes at the joint F. The vanes of the wheel are very numerous and are curved in the manner shown in Fig. 4. Each wheel is designed separately to suit the precise conditions under which it has to work.

In order that the turbine may be used with varying quantities of water, the guide blades B (Fig. 2) are pivoted close to the point and may be opened or closed at pleasure by means of the bellcranks and links shown in the illustrations.

This is a very effectual method of obtaining the best efficiency from a small supply of water, because, even when the turbine is working at half or quarter gate, the water is conducted to the wheel through long smooth and continuous channels, and is not abruptly checked in any part of its course.

According to many high authorities the inward-flow type of turbine is the best for almost every situation, since in it the water is supplied to the wheel at the circumference, where its speed is greatest, and, having done its work in driving it round, leaves at the centre at a minimum velocity.

The speed of the vortex wheel at the circumference is approximately equal to the velocity due to half the head. Thus, in a turbine working under a fall of 20 feet the speed of the periphery of the wheel is equal to the velocity of a jet escaping under 10 feet head.

When a portion of the load is taken off and the wheel begins to run faster than this speed, the extra centrifugal force which it generates checks the water from flowing into it so rapidly as it otherwise would do; if, on the other hand, a heavier load is put on and the wheel begins to run slowly, the centrifugal force is diminished and more water is admitted. This inherent tendency to self-government is of great value.

On low falls up to 8 or 10ft., the wheel is generally placed horizontally with a vertical shaft; the power is transmitted by a pair of bevel wheels to the horizontal shaft from which the dynamo is driven. The bottom end of the shaft is supported by a lignum vitæ pivot, which can be raised, as it wears, by a lever and rod. A wooden pentrough carrying strainer plates for stopping leaves, stones, &c., is placed above the supply pipe. These plates must always be kept clear. The foundations for the turbine are very simple, consisting merely of three large stones or blocks of masonry. With a higher fall the turbine wheel is usually placed in a vertical position on a horizontal shaft, from which the dynamo can be driven by a belt. As the water leaves the wheel in equal quantities at each side the wheel is always balanced, and there is no tendency to end thrust, which is an inconvenience in many turbines when placed on a horizontal shaft. When the fall is high, say over 50ft., the turbine can generally be coupled end on to the dynamo, and the whole be mounted on to one bedplate. As this arrangement dispenses with belting entirely and saves a great deal of space, it is the best when it can be adopted.

(To be continued.)

MAGNETIC PROPERTIES OF LIQUID OXYGEN AND AIR.*

BY PROF. DEWAR, LL.D., F.R.S.

After alluding to the generous aid which he had received both from the Royal Institution and from others in connection with his researches on the properties of liquid oxygen, and to the untiring assistance rendered him by his co-workers in the laboratory, Prof. Dewar said that on the occasion of the commemoration last year of the centenary of the birth of Michael Faraday he had demonstrated some of the properties of liquid oxygen. He hoped that evening to go several steps further, and to show liquid air, and to render visible some of its more extraordinary properties.

The apparatus employed consisted of the gas engine downstairs, which was driving two compressors. The chamber containing the oxygen to be liquefied was surrounded by two circuits, one traversed by ethylene, the other by nitrous oxide. Some liquid ethylene was admitted to the chamber belonging to its circuit, and there evaporated. It was then returned to the compressor as gas and liquefied, and thence, again, into the chamber as required. A similar cycle of operations was carried out with the nitrous oxide. There was a hundredweight of liquid ethylene prepared for the experiment. Ethylene was obtained from alcohol by the action of strong sulphuric acid. Its manufacture was exceedingly difficult, because dangerous, and as the efficiency of the process only amounted to 15 or 20 per cent. the preparation of a hundredweight of liquid was no light task. The cycle of operations, which, for want of time was not fully explained, was the same as that commonly employed in refrigerating machinery working with ether or ammonia.

The lecturer then exhibited to the audience a pint of liquid oxygen, which by its cloudy appearance showed that it contained traces of impurity. The oxygen was filtered, and then appeared as a clear transparent liquid with a slightly blue tinge. The capillarity of liquid oxygen, although much less than that of water, was, he stated, still considerable.

Reference was then made to a remarkable experimental corroboration of the correctness for exceedingly low temperatures of Lord Kelvin and Prof. Tait's thermo-electric diagram. If the lines of copper and platinum were prolonged in the direction of negative temperature they would intersect at – 95° C. Similarly, the copper and palladium lines would cut one another at – 170° C. Now, if this diagram were correct, the E.M.F. of the thermo-electric junctions of these two pairs of metal should reverse at these points. A Cu – Pt junction connected to a reflecting galvanometer was then placed in oxygen vapour and cooled down. At – 100° C. the spot of light stopped and reversed. A Cu – Pd junction was afterwards placed in a tube containing liquid oxygen, and a similar reversal took place at about – 170° C.

The next experiment showed that liquid oxygen presented great resistance to disruptive electric discharges. A tube filled with the liquid was placed in parallel with the discharge knobs of a Ruhmkorff coil, electrodes $\frac{1}{10}$th mm. apart being plunged into the tube. Almost all the sparking took place in air.

The spectrum of liquid oxygen was then discussed. The A and B lines of the solar spectrum had generally been attributed to absorption by the oxygen of the atmosphere. Last year M. Janssen went up Mont Blanc to test the matter, and found that the higher he went the fainter these characteristic oxygen lines became. Now, a question of great scientific interest was, were these lines maintained through the change of state from gas to liquid? Experiment showed that the lines existed in the liquid exactly as in the gas.

The next experiment was the direct liquefaction of atmospheric air under the ordinary pressure of the atmosphere. A tube containing liquid oxygen was connected to an exhaust pump, and the oxygen was evaporated at a lower and lower temperature. An inner tube was left open to the air, and in a short time was filled with liquid air, which exhibited at first

* Abstract of Friday Evening Discourse delivered at the Royal Institution, June 10, 1892.

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all the characteristics of atmospheric air and none of those of liquid oxygen. It was curious at first sight, said the lecturer, to find the two components of atmospheric air liquefying together, and not the oxygen first and then the nitrogen. This was due to the very different pressures at which the two gases were; the volume of nitrogen being four-fifths of the atmosphere and oxygen one-fifth. But once liquefied atmospheric air behaved in quite another manner. Nitrogen then boiled off first, because it had a boiling point 10° below that of oxygen. Hence, on first production, liquid air had none of the properties of oxygen; but as the nitrogen evaporated out it behaved more and more like oxygen, and finally lighted glowing matches, and exhibited the characteristic spectrum of oxygen. When placed between the poles of Faraday's electro-magnet freshly liquefied atmospheric air was seen in that case to act as a quantity of liquid oxygen, the whole mass adhering to the poles when the magnet was energised. Experiments showed that liquid atmospheric air, although containing four-fifths of its volume of nitrogen, did not have the extraordinarily high electric resistance of liquid oxygen modified in the slightest degree.

Coming then to the magnetic properties of oxygen the lecturer alluded at some length to the laborious researches of Faraday and Becquerel. In 1847 Faraday announced that oxygen was + or paramagnetic in regard to all the gases he had experimented with (air, carbonic acid, hydrogen, coal gas), but he was uncertain what medium should be taken as zero. Later on in 1849 Edmond Becquerel came to the conclusion that oxygen was truly magnetic with reference to air and vacuum. On Becquerel's scale the magnetic susceptibility of iron came out at 1,000,000, and that of oxygen at 377. When liquefied the magnetic susceptibility of oxygen rose to 1,000. Liquid oxygen was poured into a cup of rock salt placed between the poles of Faraday's electro-magnet, and on the coils being circuited the mass of liquid oxygen was seen to be lifted up and plastered against the poles until the circuit was broken, when it immediately collapsed. A U-tube containing liquid oxygen was next placed between the poles, and on the magnet being excited the liquid was sucked out. A ball of cotton wool moistened with the liquid adhered to the poles when they were magnetised. A crystal of sulphate of iron behaved in the same way after cooling by immersion.

In conclusion, the lecturer said that he had originally started on his researches interested only in the chemical side of the question. In Mendeljeef's classification the successive sets of the elements were alternately para- and diamagnetic. Now fluorine was very close to oxygen, and it was to be anticipated that fluorine would be found to be also powerfully magnetic. Then, again, there was great interest for the chemist in the chemical behaviour of bodies at low temperatures. Bodies which had violent chemical affinities under ordinary circumstances had none whatever at these low temperatures. At − 200° C. the molecules of oxygen had only one-half of their ordinary velocity and had lost three-quarters of their energy. It had seemed to him, therefore, that at these temperatures we approached the death of matter as we knew it. But perhaps he had gone a little too far, and ought not to have confined his attention to contact chemical action, and he wished to limit his previous statements on the subject. The reason which had led him to modify his views was that chemical action was still brought about at these low temperatures by radiant energy from the outside. Could we produce chemical action on a photographic plate at − 200° C.? We could, as might be seen by the view of the plate thrown on the screen, which showed that the ultra violet rays passed through liquid oxygen and did their work. From the physiological point of view also low temperatures had great interest. The spores of micro-organisms were destroyed by elevation of temperature. Were they equally destroyed by reduction of temperature? No! Pieces of putrefying materials were subjected to a temperature of − 200° C. for one hour, and commenced to putrefy on being restored to the ordinary temperature after a few days. Seeds cooled to − 200° C. afterwards fructified and developed. This lent support to a suggestion once put forward by Lord Kelvin, their chairman that evening, that life might well have been introduced into this world from another planet on the back of a meteorite.

THE BRILLIÉ METER.

Motor meters may be divided into two classes: in the one, an armature, or its equivalent, carrying the current to be measured, revolves in a permanent field, and is retarded by a force proportional to its velocity; and in the other the field varies with the current, and the retarding force varies as the square of the velocity. The Brillié meter belongs to the former class, but the motor does not carry the main current. In both classes of meters the friction of the motor, consisting of initial or static friction and of mechanical friction, must be compensated for as in the Ferranti, or masked as in the Perry meter. In this instrument the friction of the meter introduces no error, even at small loads, and only consumes a certain amount of energy. The mechanism consists of three parts—a watt-meter dynamometer with a suspended coil in a shunt circuit, a motor also in a shunt circuit, and a set of resistance coils with movable contacts.

The essential feature of this meter is the method by which the motor is regulated, by the insertion of resistances in series with it. This is effected in the following manner:—A disc of copper is suspended below the movable coil of the dynamometer, and is embraced by a system of permanent magnets, somewhat similar to those which retard the motion of the copper disc in the Elihu Thomson meter. This system of magnets is set in rotation by the motor, and the effect is to drag the copper disc back, and thus to bring the suspended coil into the zero position. A projecting arm from the suspended dynamometer coil engages with a lever which puts the resistance into circuit in three different arrangements. The wattmeter coil is thus kept in frequent oscillation, since the speed of the motor is not maintained uniform, but on the average at such a speed that the dynamometer coil remains in equilibrium. As the different contacts are made the motor receives impulses; but by its momentum it cannot respond quickly to these, and, therefore, on the average records the value of the current. The meter is sensitive, since the initial current required to start it is only that which is needed to swing the dynamometer coil round to make the first contact. This starts the motor, and this in turn drags the copper disc round, and if the current is only a small one, breaks the circuit at once. We understand that the energy absorbed by the shunt coils is about $\frac{1}{1000}$ of the total amount registered. The meter is suitable for alternate as well as direct currents, and has no frequency errors.

THE MEASUREMENT OF ILLUMINATION.*

The following article, correspondence, and editorial reply have appeared in *Industries* upon a subject touched on in the "Notes" on the first page of our issue of May 20th.

One of the most backward branches of measurement is photometry. Certainly innumerable photometers have been invented, and photometers are generally much more accurate than standards of light. Apart from designing photometers, however, little has been done in the study of illumination. Mr. Trotter's Paper, recently read before the Institution of Civil Engineers, of which an abstract appeared in our issue of the 13th ult., deals with the whole subject in a clear and scientific manner. In particular he called attention to the common confusion of the terms "light" and "illumination." We have only one objection to make, and that is to Mr. Trotter's "candle-foot" as the unit of illumination. If a unit of the sort be needed, it should be called a candle per square foot, not a candle-foot. The illumination of a surface is found by dividing the candle-power of the source of light by the square of the distance from the source, not by multiplying. A compound name like "candle-foot" always denotes multiplication, as in pound-degree, foot-pound, volt-ampere; while "per" denotes division, as in mile per hour, pound per square inch. Mr. Trotter argues that everybody knows that illumination varies inversely as the square of the distance, so that candle-foot cannot produce any confusion. But why wantonly call a thing by a wrong

* From *Industries* of May 27th and June 3rd.

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name? It would be just as sensible to speak of a pressure of 100 inch-pounds. Electricians are already inaccurate in some of their phrases; for instance, insulation resistance is frequently given in megohms per mile instead of in megohm-miles; and, in spite of M. Hospitalier, who is the soul of method in these things, some people give specific resistances in microhms instead of in microhm-centimetres.

Mr. Trotter takes the illumination due to a standard candle one foot away as unit illumination. The unit of light is then taken as the light falling on a square foot which is one foot away from the candle. This leads to the curious result that a candle gives a total light of 4π, or $12\frac{1}{2}$ candles. This seems strange to those who are not acquainted with the conventional mathematical treatment of problems in attraction, hydrodynamics, heat, and electricity. The treatment of light is exactly analogous, and so Mr. Trotter's candle which gives a light of $12\frac{1}{2}$ candles is perfectly correct. Light is on all fours, for instance, with electrostatic induction, so that illumination is a flux, and is thus measured in candles per square foot or some analogous expression. We sincerely trust that, for the sake of the peace of mind of future systematisers, Mr. Trotter will not bring the candle-foot into use, but will give us the more accurate, if cumbrous, "candle per square foot" instead.

SIR: To reply fully to the short article, in which you criticise some points raised in my recent Paper on illumination, would occupy more of your space than I can ask, and more of my time than I can at present give. A whole chapter of the science of optics yet remains to be written, and one which will prove to be of great practical value.

You would have better reason to object to "Mr. Trotter's 'candle-foot' as the unit of illumination" if I had indeed originated the unit or its name; but I understand that Mr. Sugg used it 30 years ago, and I never imagined for a moment that I was concerned with so serious a responsibility as the creation or naming of a new unit. French writers who have paid some little attention to the subject of illumination, have used the "carcel-metre" and "bougie-metre" with, in my humble opinion, such lucidity, that in spite of the protests of M. Hospitalier* and M. Weissenbruch,† I ventured to use the "candle-foot" as the British equivalent. You say, in the first place, that the unit should be called a "candle per square foot." This subject is complicated by the frequent introduction (or suppression) of unity and of its square. To be exact, if clumsy, I would rather say, "a candle per foot squared," for by "foot" I mean most distinctly the distance of the candle from the illuminated surface, and not the square root of an illuminated area. To speak of so many candles or parts of a candle per square foot is likely to lead to much more serious errors.

Mr. Preece's rule of one 16 c.p. lamp per 64 square feet of floor is sound only when it is carefully coupled with the condition that the lamp is 8ft. from the surface to be illuminated. If I specify that the average illumination of a hall is to be $1\frac{1}{2}$ candle feet, I say that nobody of ordinary intelligence can imagine that $1\frac{1}{2}$ candles at 1ft. is the same thing as 1 candle at $1\frac{1}{2}$ft.; and that should any doubt arise as to which of these is intended, reference need only be made to the unit—a candle-foot—the specified illumination being $1\frac{1}{2}$ times that unit. How to produce that illumination by the proper distribution of lamps of the necessary power, the name pretends neither to suggest nor to explain. But if the expression "$1\frac{1}{2}$ candles per square foot" be used, a person of intelligence might easily fall into the grave error of reckoning up the surface to be illuminated as so many square feet, and then apportioning $1\frac{1}{2}$ c.p. to each square foot, placing the lamps at any height or distance. He would only be justified in neglecting the height of the lamps if there were an indefinitely great number of them, and an indefinitely great area of illumination.

I admit that some little intelligence is needed to understand the "candle-foot," and agree that, as a rule, compound names denote multiplication. But you say that "it would be just as sensible to speak of a pressure of inch-pounds." There is, however, this important difference, which depends upon the meaning of the term "foot" in the expression "candle-foot," as denoting distance and not area. The "foot," as I have already claimed, is here the measure of a distance. The intensity of the illumination *depends on that distance*. An intensity is composed, it is true, of two factors—something divided by an area; but in the expression "candle-foot" I assume that the area is suppressed, and that the illumination is considered only at a point. The intensity of illumination can be measured in a more roundabout way by total light per square foot, but I contend that it is more simple to take simple candle-power and distance, thus avoiding the 4π difficulty.

* *L'Electricien*, Vol. XXX., page 521 (August 17, 1889)

† *Ibid.*, page 649 (October 12, 1889).

The comparison with "inch-pound" is, I consider, unfair, because the pressure does not depend in any way upon a distance, but is fully expressed by pounds per square inch. May I explain the suppression of the area by an analogy, a hydraulic analogy, so dear to electricians, and, as usual, misleading if pressed too far? There are three different ways of measuring rainfall. I neglect the time and deal only with the intensity. We may reckon it in gallons per acre; three dimensions of water, and two dimensions of land. Or we may take square feet of water per mile of country. The water in a river is commonly measured thus in square feet of vertical section across the stream. That is, two dimensions of water and one of horizontal length. Or we may reduce the dimensions once more, and take inches of water on a point—that is, one dimension of water and no dimensions of land. It may be argued that you cannot measure a quantity of water by linear inches, and *à fortiori*, you cannot measure a quantity of water per unit area in that way, and that dimensions which are necessary for the intelligible expression of a quantity should not be suppressed. M. Hospitalier has suggested the expression "carcel à 1 metre" for "carcelmetre," and I should very much prefer a "candle-at-a-foot" to "candle per square foot" or a "candle per foot-squared." The sole argument in favour of the "lux" as a name for this unit is that it obviates this ambiguity. I should like to see a better name, but it should be self-explanatory.

I must object to taking the unit of light "as the light falling on a square foot which is one foot away from the candle" unless the word "everywhere" be inserted before the words "one foot," showing that the square foot is part of a spherical surface surrounding the candle. From this the 4π paradox arises. But I venture again to differ with your remark that "this leads to the curious result that a candle gives a total light of 4π or $12\frac{1}{2}$ candles. Total light is the product of candle-power into a solid angle. A solid angle is measured by the area of a sphere (of unit radius) which is intercepted. To be accurate, one must say that a candle gives a total light of 4π candle-power. Some very interesting results follow from this, but I cannot enter upon them in this letter, which has already trespassed greatly on your space. To this measure total light by candle-power is a roundabout expedient, but it may be compared with the expression horse-power-hour, which is more convenient than 1,980,000 foot-pounds, or 2,685,860 joules, although it is tautological.

Total light may be measured in "candles," since it is absurd to say that a candle gives a light of $12\frac{1}{2}$ candles. The total light of 1 candle is, of course, 1 candle, and 1 candle = 4π c.p., assuming unit radius and solid angle.—Yours, &c., A. P. TROTTER.

The following editorial note was appended to this letter:—

[Mr. Trotter argues that the foot in "candle-foot" refers specifically to the distance; yet he gives inches of rain as an analogy. Here the inches have nothing to do with the distance from any source. If light accumulated on the surface till it lay a foot thick in a given time, Mr. Trotter might measure illumination in feet per year, but not in candle-feet. He might have found a much better analogy in electric or magnetic displacement which can be given as a length, but not as the product of a length and quantity, or length and strength of pole. Induction might be measured in lines per centimetre squared as well as in lines per square centimetre. But such a way of taking it, though not admissible, is unusual. Mr. Preece's rule is not to the point. What he means is, doubtless, a quarter of a candle per square foot. We are still unable to see that it is right to give a quantity a wrong name and trust to people's intelligence to know it is wrong. To specify $1\frac{1}{2}$ candles per square foot is perfectly definite, and Mr. Trotter's statement that this might lead to apportioning $1\frac{1}{2}$ c.p. to each square foot, placing the lamps at any height or distance, seems to show a confusion in his mind between candles themselves and the light they give. What we think Mr. Trotter fails to realise is that the "dimensions" are wrong in candle-foot. When we mentioned a square foot a foot away from the candle, we did not mean that some of the surface was some other distance off. This is the ordinary method of finding a solid angle of unity. We are not sure whether by "candle" Mr. Trotter means a wax cylinder with a wick or a flow of light. If he means the former a "candle-foot" is a very curious object; if the latter, which is the way we have used it, of course, a candle gives a light of 4π candles. If candle-power is light, then we consider "candle-power per square foot" is the correct unit. Mr. Trotter quotes authorities who agree with him, but there is really no such thing as authority in science. Mr. Trotter may be sinning in good company; what grieves us is that he seems anxious to go on sinning.]

THE LAUFFEN-FRANKFORT TRANSMISSION.

The following information with regard to the results obtained by the testing committee is furnished by the Council of the Frankfort Exhibition. The work of the committee consisted in testing three sets of plant.

The first was that put down by the Allgemeine Elektricitäts Gesellschaft, of Berlin, in conjunction with the Maschinenfabrik Oerlikon for transmitting 300 H.P. from the Wurtemburg Portland Cement Works at Lauffen, on the Neckar, to the Exhibition, a distance of 109 miles. The measurements were made by Prof.

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Dietrich, Dr. Feussner, Dr. Heim, Dr. Kopp, Messrs. Nizzola and Schmoller, Profs. Stenger, Teichmann, Voit and Weber. Table I. shows the results obtained. It is to be noted that column 12 gives the efficiency expressed as a percentage ratio between the energy consumed by the lamps at Frankfort and that delivered by the turbines at Lauffen. The measurements taken at Lauffen, which were carried out under Prof. Killter and Councillor Lindley, with the view of obtaining the efficiency and other interesting points with pressures of 25,000 and 30,000 volts, will be published later on with the report on the Exhibition.

The second plant reported on consisted of a 20 H.P. engine in the Palmengarten, which by means of a high-pressure continuous current drove a motor in the Exhibition at a distance of 1¼ miles. This was put down by the Deutsche Electricitätswerke of Aachen (Messrs. Garbe, Lahmeyer and Co.). In this case the measurements were taken by Prof. Brauer, Dr. Wirtz, Messrs. Friese, Stapelfeldt and Cesar, and the results are given in Table II. Column 12 in this table gives the efficiency reckoned as the ratio between the brake horse-power developed by the motor, and the whole output of the machine at the Palmengarten. The resistance of the conductor was 5·9 ohms.

On the third installation, carried out by Messrs. Lahmeyer, of Offenback, no results are yet obtainable.

Full details of all these tests, and the instruments used, &c., will be published as soon as the heavy labours of the committee are concluded.

Table I.

Time.	H.P. supplied by turbine.*	Output of dynamo.	Efficiency of dynamo.	Output of primary transformer.	Efficiency of primary transformer.	Loss in conductor.	Energy supplied to second'ry transformer.	Energy delivered by second'ry transformer.	Efficiency of second'ry transformer.	Efficiency between dynamo and consuming apparatus.	Efficiency between turbines and consuming apparatus.	Weather.
	H.P.	H.P.		H.P.		H.P.	H.P.	H.P.		%	%	
Oct. 11th.— 1:30 to 1:40	120·9	108·1	0·894	102·4	0·947	7·3	95·1	89·5	0·941	82·6	74·0	Bright, dry.
1:50 to 2: 0	121·1	108·3	0·894	102·6	0·947	7·6	95·0	89·4	0·941	82·4	73·8	
Oct. 12th.— 1:35 to 1:45	127·0	114·4	0·900	108·7	0·950	8·0	100·7	95·1	0·944	83·0	74·9	Cloudy, rain at times.
1:50 to 2: 0	127·5	114·8	0·900	109·0	0·950	8·1	100·9	95·3	0·944	82·9	74·8	
2:10 to 2:20	99·3	86·8	0·874	81·5	0·939	5·0	76·5	71·4	0·933	82·4	71·9	
Oct. 13th.— 9:50 to 10: 0	105·9	93·3	0·881	87·7	0·940	6·0	81·7	76·3	0·934	81·6	72·1	Rain till noon.
10: 5 to 10:15	105·9	93·3	0·881	87·7	0·940	5·9	81·8	76·4	0·934	81·7	72·2	
Oct. 16th.—10:45 to 10:55	151·8	139·1	0·916	132·8	0·955	12·8	120·0	114·0	0·950	81·8	75·1	Dry.
11: 0 to 11:10	151·7	139·0	0·916	132·7	0·991	12·5	120·2	114·2	0·950	82·0	75·3	
11:35 to 11:45	194·7	182·2	0·935	175·1	0·961	24·4	150·7	144·2	0·957	79·1	74·1	
12:30 to 12:40	197·4	184·8	0·935	177·6	0·961	25·2	152·4	145·8	0·957	78·8	73·9	
1:30 to 1:40	117·6	104·9	0·892	99·2	0·946	7·5	91·7	86·2	0·940	82·0	73·3	
1:45 to 1:55	112·7	100·1	0·888	94·5	0·944	6·9	87·6	82·2	0·938	81·9	72·9	
2:30 to 2:40	78·2	66·1	0·845	61·1	0·925	3·1	58·0	53·5	0·922	80·9	68·5	
Oct. 15th.—10:53 to 11: 3	190·7	177·9	0·933	170·8	0·960	25·5	145·3	138·9	0·956	77·8	72·8	Rain in early morning.
11: 5 to 11:15	190·0	177·3	0·933	170·2	0·960	24·9	145·3	138·9	0·956	78·1	73·1	
11:20 to 11:30	189·7	177·0	0·933	169·9	0·960	24·6	145·3	138·9	0·956	78·1	73·2	

* The energy taken by exciter is included.

Table II.

Primary Station. Dynamo by Deutsche Elektricitätswerke Aachen.				Secondary Machine. Motor by Deutsche Elektricitätswerke Aachen.						
Volts at terminals.	Current in amperes.	Total output watts.	Revs. per minute.	Volts at terminals.	Current in amperes.	Energy absorbed by motor.	Revs. per minute.	Load on brake lever kgs.	Load H.P.	Efficiency of motor.	Total efficiency.
1,107	13·95	15,442	511	1,045	13·95	14,578	370	15	17·44	88·10	83·10
1,124	13·90	15,624	519	1,043	13·90	14,464	375	15	17·68	89·70	83·50
977	10·55	10,307	528	932	10·55	9,832	358	5	11·87	88·80	84·70
992	10·75	10,664	526	927	10·75	9,965	361	5	11·98	88·30	82·70
1,001	10·90	10,911	527	934	10·90	10,181	364	5	12·07	87·30	81·40
970	9·70	9,408	539	899	9·70	8,720	402	0	10·52	88·70	32·10
946	9·65	9,129	538	884	9·65	8,531	392	0	10·24	88·40	82·60
941	9·65	9,081	536	896	9·65	8,646	400	0	10·46	89·10	81·80
194	1·50	291	560	175	1·50	26,250	431	running light.	..	..	...

ON THE CHANGES PRODUCED BY MAGNETISATION IN THE LENGTH OF IRON AND OTHER WIRES CARRYING CURRENTS.*

BY SHELFORD BIDWELL, F.R.S.

The changes of length attending the magnetisation of rods or wires of iron and other magnetic metals which were first noticed by Joule† in 1841, and have in recent years formed the subject of many experiments by myself,‡ have been found to be related to several other phenomena of magnetism. Maxwell§ has suggested that they sufficiently account for the twist which is produced in an iron wire when magnetised circularly and longitudinally at the same time. The resultant lines of magnetisation, as he points out, take a spiral form; the iron expands in the direction of the lines of magnetisation, and thus the wire becomes twisted. Professor G. Wiedemann, however, to whom the discovery of the magnetic twist is due, appears not to be satisfied with this explanation, believing the effect to be caused by unequal molecular friction.

The subject of magnetic twists has been very fully and carefully investigated by Prof. C. G. Knott; and in a Paper published last year in the *Transactions* of the Royal Society of Edinburgh (Vol. XXXVI., Part II., p. 485), he indicates many details in which the phenomena af twist closely correspond with those of elongation and retraction. Assuming their essential identity, and noting that "an increased current along the wire affects the points of vanishing twist in a manner opposite to that in which an increased tension affects it," Prof. Knott is "inclined to conclude that the pure strain effects of these influences are of an opposite character." Now, since the magnetic elongation of an iron wire is known to be diminished by tension, the remark above quoted amounts to a prediction that in an iron wire carrying a current the magnetic elongation would be increased. "We know nothing so far," Prof. Knott ob-

* Abstract of a Paper read before the Royal Society, May 19th, 1892.

† "Joule's Scientific Papers (Phys. Soc.)," pp. 48, 235.

‡ *Phil. Trans.*, Vol. CLXXIX., A, p. 205; "Roy. Soc. *Proc.*," No. 237 (1885), p. 265; No. 242 (1886), p. 109; No. 243 (1886), p. 257; Vol. XLIII., p. 406; Vol. XLVII., p. 469.

§ "Electricity and Magnetism" Vol. II., § 418.

‖ *Phil. Mag.*, July, 1886, p. 50.

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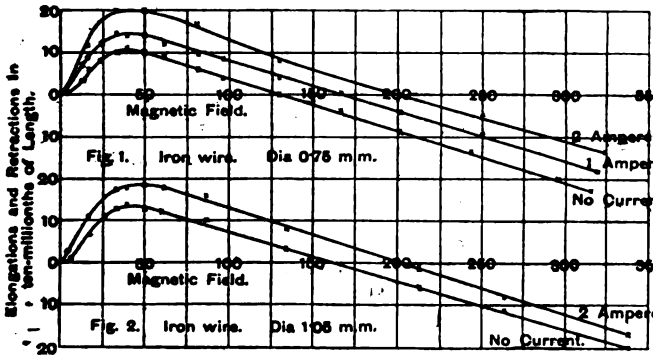
serves, "regarding the changes of length when an iron wire *carrying a current* is subjected to longitudinal magnetising forces;" and it was with the object of acquiring some information on this point and testing Prof. Knott's prediction that the experiments described in the present Paper were undertaken. The results show that it was amply verified, and thus Maxwell's explanation of the twist receives still further corroboration.

The apparatus used and the methods of observation were the same as those described in former papers. Each specimen of wire examined was 10cm. long between the supporting clamps, and the magnetising coil, weighing nearly 3lbs., was as usual supported by the wire itself, an arrangement which, for reasons before given, was essential. The indications of the instrument were read to one ten-millionth part of the length of the wire, and the wire was demagnetised by reversals before each single observation.

Exp. 1.—The wire first used was of soft commercial annealed iron, 0·75mm. in diameter. The changes of length which it exhibited under the influence of magnetising forces gradually increased from 13 to 315 C.-G.-S. units, are indicated (Fig. 1). The magnetising forces given are those due to the coil only, no account being taken of the demagnetising effect of the wire. It will be seen that the maximum increment of length, attained in a field of about 40, was 11·5 ten-millionths; the decrement of length in a field of 315 was 22·5, while the original length of the wire was unchanged in a field of 130.

Exp. 2.—A current of 1 ampere was then passed through the wire. In about two minutes the index came to rest, the number of scale divisions over which it had passed showing that the original length of the wire had increased by 310 ten-millionths. Assuming the coefficient of expansion of the iron to be 122 ten-millionths per degree Centigrade, this elongation denoted a rise of temperature (due to current heating) of about 2°·5. The experiment described in the last paragraph was then repeated, the several magnetising forces employed being made as nearly as possible the same as before by inserting the same resistances successively in the circuit.



The results appear in the middle curve of Fig. 1. The latter shows clearly that the maximum elongation had risen from 11·5 to 14·5 ten-millionths, while the decrement in a field of 315 had fallen from 22·5 to about 17·5.

Exp. 3.—The current through the iron wire was then increased to 2 amperes. The further elongation of the wire (due to the heating effect of the increased current) was very nearly 1,000 ten-millionths, corresponding to a rise of temperature of 8°·2 C. This, added to 2°·5, the rise due to the current of 1 ampere, which was passing before, give 10°·7 as the excess of the temperature of the wire carrying 2 amperes above that of the room. When the index had become steady, which happened in the course of about 2½ minutes, another series of observations was made. The results of the experiment are contained in the highest of the curves in fig. 1. There is again a marked increase of the maximum elongation, and decrease of the retraction in a field of 315.

Exp. 4.—The previous observations were repeated with another specimen of soft iron wire of greater diameter, viz.: 1·05 mm., no current being at first passed through it. The results appear in fig. 2.

Exp. 5.—A current of two amperes was passed through the same wire, resulting in an elongation due to heating of 460 ten-millionths, the temperature of the wire being therefore raised about 3°·3. The former observations were again made with the results given in fig. 2.

It will be seen that with both specimens of iron wire, the effect of a current is of just the same general character. It acts oppositely to tension, heightening the curve of elongation instead of lowering it. This action is certainly not due either directly or indirectly to mere current heating. It has been shown that the thinner wire, even when carrying two amperes, was only about 10°·7 warmer than when no current was passing through it. Such a small rise of temperature would be quite incompetent by itself to account for the effect in question, for the elongation curves of a given specimen of iron have been found to be not sensibly altered when taken under widely different conditions of temperature. Nor would it exert any material influence upon the susceptibility of the iron; and, even if it did, the curves would not be affected in the manner observed. It is hardly worth while attempting to frame an explanation until many more phenomena of the same order have been investigated.

Similar experiments were afterwards made with nickel and cobalt.

Summary.

In an iron wire carrying a current, the maximum magnetic elongation is greater, and the retraction in strong fields is less than when no current is passing. The effect of the current is opposite to that of tension.

The magnetic retractions of nickel and of cobalt are not sensibly affected by the passage of a current through the metals. (Tension considerably modifies the magnetic retraction of nickel, but not that of cobalt.)

PHYSICAL SOCIETY.

At an ordinary meeting of this Society on the 10th inst., Dr. GLADSTONE read a Paper by himself and Mr. W. HIBBERT on

"Some Points connected with the Electromotive Force of Secondary Batteries."

Last month we communicated a Paper to the Institute of Electrical Engineers, "On the Cause of the Changes of Electromotive Force in Secondary Batteries," which gave rise to a certain amount of discussion. Since then we have received a Paper by M. Darrieus, entitled "Essai de Théorie Chimique sur les Accumulateurs Electriques au Plomb;" which was read before the Société Internationale des Electriciens on May 4th. In it he agrees with Prof. Armstrong and Mr. Robertson in attributing the large initial electromotive force to persulphuric acid; and he opposes what he terms the most generally admitted theory of the production of sulphate during discharge, so far as the positive plate is concerned.

In our recent Paper we had assumed the truth of the view put forth by Messrs. Gladstone and Tribe in 1882, that in discharge "sulphate of lead is the ultimate product on both plates," and on discharging again "this lead sulphate is oxidated on the one plate and reduced on the other." This conclusion was not received at first without powerful opposition; but it has won its way to general acceptance among workers on the subject. Among these may be specially mentioned Prof. Frankland, Mr. Swinburne, M. Reynier, Messrs. Kohlrausch and Heine, Prof. Ayrton and his colleagues, and Mr. G. H. Robertson.

We can only attribute the finding by M. Darrieus of a large amount of oxide of lead mixed with sulphate on the positive plate to the fact of the difficulties of analysis, as it is hard to imagine that oxide of lead could remain as such when surrounded by sulphuric acid.

The reaction which takes place in discharging was expressed in our recent Paper by the general equation—

$$PbO_2 + H_2SO_4 \ldots H_2SO_4 + Pb = PbSO_4 + H_2O \ldots H_2O + PbSO_4,$$

and the reaction that takes place on charging was expressed by the same equation reversed. It is to be understood that these equations represent the initial and the ultimate products, and take no note of any intermediate reaction. There have been numerous theories in regard to such intermediate changes, but on these we must be held at present to express no opinion.

It is evident that if the reaction consists in the alternate formation and reduction of $PbSO_4$ there must be great changes in the strength of the sulphuric acid within the pores of each plate. How these changes must be affected, not only by the electrolytic reaction, but by the influence of gravitation and of diffusion, by electrical transference, by local action, &c., is traced out in our Paper. At the same time, continuing the experiments which were communicated to this society in 1890, we have not merely satisfied ourselves more fully that a change of strength of acid against the working surfaces of the plates results in a change of electromotive force, but we have determined the amount quantitatively for all strengths of acid from a mere trace to 99 per cent.

We show that the changes of electromotive force in charge and discharge coincide fairly well with the changes of strength of acid deduced *à priori*. For this purpose we employed the determinations lately published by Prof. Ayrton and his colleagues, believing them to be the best. Our conclusion is "that the changes of electromotive force in a secondary battery depend on the strength of the acid that is against the working surfaces of the plates."

The only serious opponents of our views, so far as we know, are Messrs. Armstrong and Robertson. They have attributed the changes of electromotive force to the persulphuric acid and hydro-

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gen dioxide which are produced during the charge. The experimental grounds of this conclusion are not yet fully published ; but we are able to refer to their remarks in the discussion of our Paper, as printed in *The Electrician* of June 3, 1892. They commence by substituting for our general equation a complicated and unsymmetrical one, which at best can only be one form of it, and cannot represent those of our experiments that were made with the strongest sulphuric acid. Their subsequent remarks are addressed mainly to the supposed contamination of our sulphuric acid with the soluble peroxides, and to the probability of H_2SO_4 itself taking part in the reaction. Now, as to the first objection :—

Supposing that our plates in the first instance were not washed perfectly clean, there can be no reason why the trace of peroxide should always vary in amount with the strength of the fresh sulphuric acid in which the plates are dipped. As to the second objection, we have not speculated on hydrates of sulphuric acid in solutions, and have expressly stated that we "content ourselves at present with pointing out that the liquid in the secondary cell is a mixture, or a chemical compound, of two different liquids, sulphuric acid (H_2SO_4) and water, in varying proportions."

The most tangible criticism is directed not against our main experiments and argument, which are untouched, but against one of our confirmatory experiments. Messrs. Armstrong and Robertson say, "Two series of experiments were described by the authors, in which the electromotive force developed on the one hand between two lead plates and on the other between two peroxide plates in acids of different strengths, were measured. They appeared to regard these results as very important, as they went so far as to draw conclusions from a curve obtained by integrating the two sets of observations." They might have added that this curve coincides both in shape and magnitude with that previously determined when a Pb and PbO_2 plate were placed together in different strengths of acid. They attribute the results obtained with the two peroxide plates to the lead supports, because "local action would set in and be at a maximum in the stronger acid, and, therefore, the lead plate of this couple would be more protected, and the support opposite would be more active against the peroxide of this plate." The explanation is ingenious ; and we might welcome it, since it presupposes the truth of our own conclusion, that with a stronger sulphuric acid there is greater electrolytic action. It is, indeed, not impossible that the lead support may in some cases have a small influence on the result, but it is inconceivable that such large and uniform differences and such close coincidences as those shown in our Paper could be due to the accidental operations of local action. In this connexion they claim support from an experiment of ours with a plate dried at 100 per cent.; but a reference to Table 5 will show that in that experiment of ours we obtained not the highest, but really the lowest readings.

In order to show that the increase of electromotive force does not depend upon the presence or absence of persulphuric acid, we have within the last few days instituted the following two additional experiments. 1st. A Pb plate and a PbO_2 plate, perfectly free from dissolved oxides, were placed in pure sulphuric acid of 12 per cent. strength, a porous diaphragm being between the two. The electromotive force was 1·945. Into the acid surrounding the PbO_2 plate was placed one per cent of persulphate of potassium ; the electromotive force remained at 1·945. The lead plate was then brought into the same compartment, so that both were exposed to the influence of the persulphuric acid. The electromotive force was scarcely changed, viz., 1·934. 2nd. A secondary battery was made with phosphoric acid instead of sulphuric acid. Observations were made with different strengths of this phosphoric acid, varying in specific gravity from 1·05 to 1·5. The electromotive force increased with the strength of the acid ; and in the full range there was a difference of 0·196 volt. The theoretical variation calculated by Lord Kelvin's thermo-chemical law from the known heat of dilution would be about 0·170 volt. Of course there was no persulphuric acid, and we cannot assume the presence of any higher acid oxide of phosphorus corresponding to it, as such a compound is not known.

We have investigated the effect of charging and repose on the electromotive force of a small accumulator with phosphoric acid as the electrolyte, and found the results quite analogous to those obtained with sulphuric acid, as described in our Paper read at this Society in 1890, when we first announced our view that "the abnormal amount of electromotive force is due to the inequality of acid strength, and its gradual disappearance to equalisation of strength produced by diffusion."

Prof. AYRTON thought there was no question that the strength of acid had much to do with the changes of E.M.F. The point at issue, he considered, was whether the changes were direct effects of the strength of acid, or due to secondary actions brought about by alterations in strength.

Mr. E. W. SMITH said Mr. Robertson and himself were repeating the author's experiments with two PbO_2 plates without any grid. They had obtained results analogous to those mentioned in the Paper, but the true explanation of the effects was still to seek.

Mr. W. HIBBERT contended that the soluble oxides referred to by Prof. Armstrong and Mr. Robertson were not present in their experiments. They had also proved that changes in acid strength altered the E.M.F., whilst presence of persulphuric acid did not.

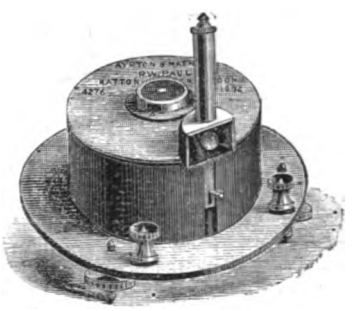
Dr. GLADSTONE, in reply, said they also were making experiments without grids, but had not made sufficient progress to discuss them at present. Mr. Hibbert and himself believed the effects of local action inconsiderable, whilst Messrs. Armstrong and Robertson thought them very important. He hoped that ere long the points would be settled conclusively.

Prof. AYRTON then read a Paper by himself and Mr. T. MATHER on

"Workshop Ballistic and other Shielded Galvanometers."

The galvanometers described were of the type having movable coils and fixed magnets, the advantages of which are well known. In designing the ballistic instruments their aim had been to obtain sensibility and portability, combined with being screened from external influences, for it was often desirable to measure the magnetic fluxes and fields in dynamos by apparatus near the machines. One of the improvements adopted was the narrow coil described in a Paper "On the Shape of Movable Coils," &c , read before the Society in 1890. Such coils are particularly advantageous for ballistic instruments, for not only can greater swings be obtained by the discharge of a given quantity of electricity through such a coil, than with ordinary shaped coils when the periodic times are the same, but even when the same control is used, the same length of wire in the coil, and suspended in the same field, the narrow coil is more sensitive to discharges than coils of any other shape. Another improvement was the use of phosphor bronze strip for the suspensions, instead of round wire. For a given tensile strength, both the control and the sub-permanent set could be diminished by using strip.

In February, 1888, the authors made a d'Arsonval of the ordinary type as a ballistic instrument, and found that although it was suitable for comparing condensers, yet for induction measurements the damping was excessive unless the resistance in the circuit was very large ; this greatly reduced the sensitiveness. In 1890 they tried one of Carpentier's milliampere meters as a ballistic instrument, but found it unsensitive. A narrow coil instrument made in the same year was found to be sensitive for currents ; but as the



coil was wound on copper to get damping, it was not suitable for ballistic work. In January, 1892, a somewhat similar instrument was constructed for ballistic purposes, and was found very sensitive and convenient. Although the coil had only a resistance of 13 ohms, one microcoulomb gave a swing of 170 divisions on a scale 2,000 divisions distant, the periodic time being 2·7 seconds. The instrument could be used near electro-magnets or dynamos, and was so sensitive that for ordinary induction measurements very large resistances can be put in series with it, thus reducing the damping to a very small amount. On the other hand, the coil could be brought to rest immediately by a short-circuit key. It had the further advantage that it was not necessary to redetermine its constant every time it was used. The chief disadvantage of such instruments was the variable damping on closed circuits of different resistances. This could, however, be overcome by arranging shunts and resistances so that the external resistance between the galvanometer terminals was the same for all sensibilities. A portable ballistic instrument intended for workshop use was next described. This had a narrow coil and a pointer moving over a dial, whose whole circumference was divided into 200 parts. The instrument had been designed to give a complete revolution for a reversal of a flux of two million C.-G.-S. lines, but the pointer could turn through two or more revolutions. To test stray fields a test coil with a total area of 10,000 square centimetres is used, and has a trigger arrangement for suddenly twisting it through two right angles. The instrument then reads off directly the strength of field in C.-G.-S. lines. To vary the sensitiveness in known proportions resistances are employed.

Referring to the improvements made in movable coil instruments since January, 1890, when a Paper on "Galvanometers" was read before the Society by Dr. Sumpner, and the present authors, Prof. Aryton said Mr. Crompton had greatly increased the sensitiveness of Carpentier's instruments by suspending the coils with phosphor bronze strip. Mr. Paul had brought out a narrow coil instrument (*see* figure) which combined the advantages of portability, deadbeatness,

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quickness and sensibility. Specimens of these instruments were exhibited. The narrow coils are enclosed in silver tubes, which serve to damp the oscillations. Such a coil is suspended within a brass tube, which also forms the mirror chamber, and slides down between the poles of a circular magnet fixed to the base. To clamp the coil, a plug mounted on a slotted spring passes through a hole in the brass tube. A tube can be taken out and replaced by another containing a coil of different resistances in a few seconds. An instrument of this kind, with a coil of 300 ohms, gave 95 divisions per microampere, and the damping on open circuit such that any swing was ⅓ of the previous one. On comparing recent instruments with those mentioned in the Paper on "Galvanometers" above-referred to, a distinct improvement is apparent, for their sensitiveness is, for the same resistance and periodic time, as great as that of Thomson instruments.

Prof. PERRY remarked that the forces dealt with were extremely small.

Mr. SWINBURNE thought that ballistic galvanometers might be regarded as instruments indicating the time integral of E.M.F. rather than quantity. Illustrating his meaning by reference to dynamos, he said that if two machines arranged as dynamo and motor were joined by wires, then if the armature of the dynamo were turned through any angle, that of the motor would move through the same angle, supposing friction, &c., eliminated. Speaking of figures of merit he pointed out that the power consumed was the important factor.

Prof. S. P. THOMPSON inquired what was the longest period yet obtained with narrow coil instruments. The decay of magnetism in large dynamos was so slow that very long periods were required. He himself had used a weighted coil for such measurements. He also wished to know why the figures of merit were expressed in terms of scale divisions on a scale at 2,000 divisions distance, instead of in angular measure or in tangents. He thought that in testing magnetic fluxes by the workshop ballistic instrument the test coil might be left in circuit, instead of putting in another coil.

Mr. E. W. SMITH asked what was the length of strip required to prevent permanent set when the deflection exceeded a revolution.

Mr. A. P. TROTTER wished to know what error was introduced by the change of damping caused by the resistance of the circuit not being quite constant.

In his reply, Prof. AYRTON said Mr. Boys had pointed out that the scientific way to lengthen period was not by weighting the coils or needles but to weaken the control. Periods of 5 seconds had been obtained. At present it was not easy to obtain longer periods, owing to difficulties in obtaining sufficiently thin strip and to the magnetism of materials.

OVERHEAD WIRES.

LONDON COUNTY COUNCIL BY-LAWS.*

The Special Committee which was appointed at the recent annual meeting of the Electrical Trades Section of the London Chamber of Commerce to consider and take action in regard to the County Council by-laws, has drawn up a petition, of which the following is a copy, and which is being presented to the Board of Trade in the name of the Chamber:—

The petition of the Incorporated Chamber of Commerce of London humbly showeth:—

1. That your petitioners, on behalf of its Electrical Trade Section, are interested in the "by-laws made by the London County Council in pursuance of the London Overhead Wires Act of 1891," and objections to which are shortly to be heard, and the clauses finally settled by your department.

2. That having considered the by-laws which the London County Council are empowered to frame under the Act, your petitioners have arrived at the conclusion that many of the provisions are wholly impracticable, and would place such insurmountable difficulties in the way of the companies interested, as to prevent them carrying on their business, and are quite unnecessary for the public safety.

3. That your petitioners aver that the Companies fully realise that it is in their own interest and that of the electrical industry generally that proper safeguards should be provided for the safety of the public from accidents arising from carelessness in the erection or maintenance of overhead wires.

4. That your petitioners are prepared to co-operate, if need be, in the framing of any reasonable legislation for the proper control and regulation of overhead wires in the County of London, and would wish to indicate that they regard the by-laws framed and recently passed by your department for the regulation and control of overhead wires in the provinces as being generally reasonable, and such as will not stultify and hamper the development of the industry, while at the same time sufficiently safeguarding public interests.

5. That your petitioners object to Clauses 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 19, 20, and 21 of the regulations as now framed by the County Council, the reasons, where such are given, being here set opposite the numbers of the clauses referred to.

Interpretation of Words.—That the interpretation of "company" as including "person" may be taken to mean any person using a wire—*e.g.*, a subscriber to a telephone company.

Clause 1.—That the "plan" which is required is in excess of the powers granted to the London County Council under Clause 5 of the London Overhead Wires Act of 1891. That the regulation is an impracticable one. That to comply with it a special staff of clerks and inspectors would require to be continually employed in view of the constant changes which are being made in the routes of wires to suit the requirements of telephone subscribers. That the attendant expense would be very serious, and even if practicable, the time allowed (three months) is much too short.

Clause 2.—That the requirement of fourteen days' notice giving particulars of the wires proposed to be erected is far too long, inasmuch as wires have frequently to be erected and removed at a day's notice, *e.g.*, in the case of visits of royal personages, and also police requirements where only a few hours are allowed. That even in ordinary circumstances, it would be impossible to comply with the regulation, the route of the wire having to be so often changed in the course of construction. That the provincial by-laws recently settled by the Board of Trade under the Public Health Act provide only for a *route form* without drawings, being sent in one month *after erection*, and this it is contended would be sufficient in the case of London.

Clause 4.—That to require that all wires shall not be at a less height above the roof of any building than seven feet would, unless accompanied by compulsory wayleaves, make overhead wires almost impossible in some districts of London owing to the irregularity of the buildings. The enforcement of the clause would be a serious interference with the use of poles and standards. The height can add neither to the safety of the wire or its supports, nor, consequently, to the safety of the public. No such provision has been insisted upon in the provincial by-laws.

Clause 5.—That the London County Council should have power to permit an excess of 140 yards in special cases.

Clause 6.—That it is impossible to determine the angle in the case of many of the London streets, owing to their irregularity. That no similar regulation is contained in the provincial by-laws.

Clause 7.—That the words after "length of span" should be deleted so as to correspond with the provincial by-law.

Clause 8.—That no restriction should be placed on the Companies which would prevent the use of copper, as would be the case if this clause were insisted on. The enforcement of the clause would necessitate the removal of the present wires and the substitution of others, if indeed it is possible to find a wire by which the factor of safety required under the conditions could be guaranteed.

Clause 9.—That the word "pole" should be substituted for "support.'

Clause 10.—That the terms of the by-laws are in excess of the powers conferred on the London County Council under the Act. That no such enactment is provided for in the provincial by-laws.

Clause 11.—That this clause is a most unreasonable restriction, which, as has been proved by past experience, is quite unnecessary. That at least four times as many wires are carried on the present poles, and that to require that only 20 shall be erected where so many have hitherto been used with safety is to aim at the total and complete extinction of the entire overhead system, and consequently at the stoppage of all telephone exchange business in London.

Clause 12.—That cables are now in use weighing 6lb. per yard, and have not proved to be in any way dangerous, and further, that they have been erected for years weighing 2lb. per yard instead of 11lb., as mentioned in the clause, and that not a single case is known of a broken cable. That even if practicable the carrying out of the clause would prove to be so costly as to be absolutely prohibitive. Moreover, that experience proves it to be quite unnecessary, and that it is beyond the powers conferred by the Act.

Clause 14.—That to insist on the shoes of supporting poles being of iron is to resort to an old-fashioned system which might prevent the adoption of improved methods. That no such provision is contained in the provincial by-laws.

Clause 15.—That there is frequently great difficulty in efficiently connecting the wire to earth. That owners and tenants of property have grave objections to the erection of lightning conductors, and often refuse sanctioning the erection of any wires on such a condition. That a lightning conductor might prove to be a source of greater danger than protection to tenants of buildings. That such a provision is not contained in the provincial by-laws.

Clause 19.—That for this clause, No. 3 of the provincial by-laws should be substituted, which reads:—"Every wire or tube, after it has ceased to be used for the purpose for which it was stretched or placed, or for some similar or other proper purpose, must be removed, unless its owners intend within a reasonable time again to take it into use."

Clause 20.—That the Act does not provide for inspection, and that the clause is, therefore, *ultra vires*. That in any case it should be deleted, it being unreasonable to suppose that the companies can contract for the invasion at any time of business or domestic privacy.

Clause 21.—That the words "or any of the provisions of the London Overhead Wires Act, 1891," should be deleted, your petitioners being of opinion that the Local Authority has only power to impose penalties for the violation of its by-laws, and that a violation of the provisions of the Act can only be dealt with under common law procedure.

Your petitioners for the reasons given are of opinion that the London County Council by-laws, as at present framed, are utterly impracticable and so unworkable as to defeat the object they have in view, which object your petitioners are interested in promoting by all reasonable means. That the by-laws should, therefore, be amended by your department in accordance with the views here set forth, and which will, no doubt, be supported by the independent testimony and technical knowledge of the representatives of the companies interested, and that while efficient safeguards for the public safety ought to be provided, this it is contended, can be done without ruthlessly interfering with the ordinary business methods of not only a growing but an indispensable industry to the public convenience

See *The Electrician*, December 11, 1891, page 149.

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PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—THURSDAY, JUNE 9TH.

Select Committee on the Electric Railway Schemes.

The Great Northern and City Bill came on Thursday last week before the Select Committee presided over by Sir John Kennaway. Mr. Cripps, Q.C., Mr. Moon, and Mr. Tyrrell appeared for the promoters. Petitions against the Bill were presented by the Commissioners of Sewers of the City of London (counsel reserved), the Corporation of London (counsel reserved), the North Metropolitan Tramways Company, for whom Mr. Pope, Q.C., Mr. Rickards, and Mr. Richardson appeared; the Metropolitan Railway Company, for whom Mr. Littler, Q.C., and Mr. Worsley Taylor, Q.C.; and the Gaslight and Coke Company, the London Hydraulic Power Company, and the Vestry of St. Mary, Islington, for whom there were no appearances.

Mr. CRIPPS, in opening the case for the promoters, said the proposal in the Bill was for a line running from Moorgate-street, in the City, to a junction with the up and down lines of the Great Northern Railway, near Finsbury Park Station. The first line would form a junction with the up line of the Great Northern main line, the second would form a junction with the down line, and the third, starting from Drayton Park, to the City, the three lines forming the connection between the City and the Great Northern system. Between the two termini there was a very important traffic, and three stations were proposed, one at Drayton Park, one at Essex-road, and one at Old-street, in addition to the terminal station at Moorgate-street. The purpose of the line was on the one hand to give relief to the suburban traffic of the Great Northern Railway, which had increased enormously, and, on the other hand, to accommodate a very important local or omnibus traffic between Drayton Park and Moorgate-street in the City. There was a main point of difference between this proposal and the Baker-street scheme, on account of the junction proposed. The diameter of their proposed tube was 16ft., and that would enable them to run trains from the Great Northern main line over their line into the City. It was felt that the traffic could not have been dealt with by any system of changing trains. There was no question of the practicability of a system of electricity for a line of this kind. Near Drayton Park there would be a depôt for the development of their electrical power, and from there to the City the trains would be run by electric power. The traffic from the North of London, from Enfield, East Barnet, High Barnet, and Edgware, all concentrated at Finsbury Park, and could be carried forward either by the Metropolitan line from King's Cross to Moorgate-street, or by the North London line to Broad-street; but in spite of this the traffic had assumed such congested proportions that some relief must be given. On the Great Northern 85 trains were run each way a day, 48 by the London, Chatham and Dover to Victoria, and 80 each way by the North London to Broad-street at the present time. The traffic over the Great Northern system had developed at the rate of nearly an additional million a year.

Sir DOUGLAS FOX, C.E., who was the first witness, stated that he was engineer for the line jointly with Mr. Greathead. Their first idea had been to lay out a line somewhat similar to the other lines which were before the Committee, and to run it up to Finsbury Park, and have an exchange station with the Great Northern Company there. They found, however, afterwards that the Great Northern Company made it a *sine quâ non* that they should be able to run their suburban trains straight through without a change of carriage. In this particular case it would have cost them as much to construct a smaller line up to Finsbury Park as it did now to make this larger line terminating at Drayton Park. They found that they could construct a line in a 16ft. tunnel capable of taking all the rolling stock of the Company as far as Drayton Park. There were large numbers of the working classes employed about Old-street and Essex-road who would be glad to avail themselves of the facility afforded by this line of getting farther out into the suburbs. The gradients and curves on the line were, he thought, very satisfactory for accommodating the main line traffic of the Great Northern. The steepest gradient was 1 in 45 on the first line, on the second there was a small piece of 1 in 53, and on the third 1 in 66. The estimated cost was £1,199,325, to which must be added £250,000 for the lifts, electric installation, and plant. It was proposed to put the installation close to the Drayton Park Station, at a point that was away from all houses, and where there would be no difficulty. The line would be about 2½ miles in tunnel and 3 miles altogether. Excluding Sundays and holidays, they estimated that the return would be 5s. per train mile, giving net earnings for the year of £62,360. A Great Northern engine would run from Finsbury Park to an electric engine from Drayton Park to the City.

Several residents from the north of London having given evidence with regard to the insufficient train service to the City at present existing,

Mr. ALEXANDER SIEMENS was called, and, in reply to Mr. Pope, said he was interested in the question of the increase of size of the ordinary electric locomotive which would be necessary on this line. The difficulty has been to convince people that they can invest their money safely in larger locomotives. I believe that electric traction can only be applied economically in cases where there are frequent trains for long hours. Therefore electric traction, *primâ facie*, is only applicable to suburban lines or tram lines where there can be a frequent service throughout the day. If there were not frequent trains it would be very costly to apply electrical power; but then there would be other considerations, such as ventilation, which make electrical power desirable, even if it was not as cheap as steam power. I certainly anticipate that the electrical power will prove to be cheaper than steam.

But at all events there is no instance in the world, is there, of the application of electricity as a motive power to a full-sized locomotive?—I am not quite certain about that, because the Thomson-Houston Company have the order to supply full-sized locomotives to take the ordinary traffic of the Baltimore and Ohio Railway from Baltimore.

That would be reducing to practical results what at present is rather scientific opinion?—Well, I do not know whether you can call it simply scientific opinion, because if you know the weight of the train and the speed, and the line over which you draw it, you know the power you want, and then you know also what weight your locomotive ought to have. Therefore, it is not an unknown quantity; we know, for instance, that the locomotive to draw an 80-ton train ought to weigh at least 40 or 50 tons, and that it ought to exert an average power of 160 H.P., or a maximum power of very nearly 700. There is no difficulty in constructing dynamo machines which exert that power, and, therefore, from an engineering point of view, there is no difficulty whatever in making these engines; the difficulty rather is to get the public to invest their money in them.

Mr. LITTLER: What is the length of that small experimental piece of line on the Baltimore and Ohio Railway?—I believe about four miles. It is a tunnel.

Is there any experience whatever which would guide us as to the cost of this undertaking?—The nearest approach is the City and South London.

And the City and South London is 75 per cent. working expenses?—Well, you cannot take them altogether as examples, because there are difficulties which you can avoid in a new line.

With regard to capital cost?—No, with regard to working expenses. I think they have an unusual amount of repairs to do.

Is there not any line which is on all fours with this line?—There is the experience of the central stations for electric lighting, which generate electricity just the same as the station at Drayton Park will have to do; because it is entirely the same whether the electricity is used for lighting or for power.

The lighting electricity is sent along wires, is it not, and this is to be used wo king along the railway, you are to have your cars drawn by it, and you are to use it not as a lighting agent but as a motive agent. Is there no experience of it as a motive agent except the City and South London?—Any amount.

On a railway?—No, not on a railway.

Mr. CRIPPS: I see that in giving evidence before the Joint Committee you spoke specially of this Great Northern and City line. Taking the necessary horse power here do you provide and guarantee the necessary locomotives?—Certainly.

The CHAIRMAN: You have no doubt in your own mind that it can be done?—None whatever.

Sir HENRY OAKLEY, General Manager of the Great Northern Railway, was then called. He said the Great Northern Company would welcome the new line as an additional means of relieving their congested traffic. There would be no difficulty he thought in changing the engines at Drayton Park Station. At the present time they could not send any greater traffic over their rails during the busy times of the day. The route went so directly to the heart of the city that he could not doubt that such a line would prosper independently of their own.

At the close of the promoters' case Mr. Littler applied for a Speaker's Order to ensure the attendance to-morrow of the four gentlemen nominated as Directors of the railway, Baron Camoys, Mr. D. Bayley, Mr. J. H. Borrer, and Mr. R. Richards, in order to show how they proposed to raise the capital, but the application was refused.

After hearing some further evidence the Committee adjourned.

FRIDAY, JUNE 10TH.

On Friday Sir John Kennaway's Select Committee again sat to consider the Great Northern and City Bill. It was intimated that the Committee would not deal with the remaining Bills this Session.

Mr. BELL, the manager of the Metropolitan Railway, was then recalled. He said that if the Great Northern Railway were to run their trains as regularly as they ought, it would make a great difference in the receipts of his line. His Directors had tried to make arrangements for electrical experiments to see if the railway could be worked in that way, and had offered very favourable terms to electricians, but without so far obtaining any result. Omnibuses and trams put on overhead along the route of the Metropolitan Railway had seriously affected the traffic on the line. When the Walham Green 'bus was put on from King's Cross, it affected their receipts to the extent of £200 per week. There was no comparison between the Metropolitan Railway and the one now proposed. The number of passengers who came to them from the Great Northern a year was 7,000,000, for whom they received £22,000. From the four companies who worked over their line they received £92,000 a year.

Sir E. WATKIN, Chairman of the Metropolitan Railway, was the next witness. He regarded the line as practically an extension of the Great Northern to the City. He did not think that the Great Northern ran a maximum number of trains over their line during the busy times of the day, because they ran at irregular intervals of 7, 9, and 10 minutes, and so on.

Mr. LITTLER urged that the Metropolitan Company would not have contracted to pay £14,000 a year for the two lines constructed between King's Cross and Moorgate-street if they thought their traffic would be afterwards taken away from them by a scheme such as the present one. The time he thought had not come for all these experiments. If they did not succeed they would be absolutely useless and would obstruct the advancement of other schemes. He suggested that a trial should be given to one of them, the Central London, for instance. The City and South London Railway had been a failure up to the present time.

Mr. W. E. HAMMOND, Traffic Superintendent of the North Metropolitan Tramways Company, was then called to give evidence in opposition to the Bill. Their mileage was 49, which returned £28,600 per mile. Last year they carried 15,270,000 passengers, their earnings being £430,000 gross and £94,812 net. The proposed line would very seriously compete with the business of his Company.

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Mr. POPE then addressed the Committee on behalf of the North Metropolitan Tramways Company, and contended that it had not been ascertained that the creation of the power necessary to move the weight proposed could be sufficiently remunerative to justify such an expenditure. They were asked to introduce a competition to an existing statutory company created under special circumstances. He did not say any man was to blame for spending his money in advancing electrical science; but some people were, perhaps, unduly tempted sometimes in the interests of science to risk unwisely the little they had gained, and it was scarcely advisable to give any additional impulse to speculation of this sort.

Mr. CRIPPS, for the promoters, stated that if the Committee passed the preamble they would do all they could to meet the Tramways Company and their other opponents on points of difference.

The CHAIRMAN announced that the Committee considered the preamble passed. Clauses were then gone into, and the Bill was ordered to be reported to the House for third reading.

WEDNESDAY, JUNE 15TH.

Select Committee on the Telegraphs Bill.

The Select Committee of the House of Commons, to which the Telegraphs Bill now before the House has been referred, met on Wednesday; and, in the absence of the Chancellor of the Exchequer, the chair was taken by Sir James Fergusson. The other members of the Committee are, Mr. Crilly, Mr. W. Cross, Mr. John Ellis, Colonel E. Hill, Mr. Atherley Jones, Mr. Lafone, Mr. Leon, Mr. Summers, Mr. Taylor, Mr. Shaw Lefevre, and Sir Richard Temple.

Mr. J. C. LAMB, Assistant Secretary to the Post Office, who was the first witness, said that about 90 or 95 per cent. of the telephonic business of the country was now conducted by companies. The Post Office had exchanges with several important towns, however; they had a very considerable exchange with Newcastle-on-Tyne and the neighbouring towns, a flourishing exchange with Hull, one in which the colliery districts and the towns of South Wales were combined, one with Leicester, and with one or two other places. The necessity for the present Bill had been felt for some time, owing partly to questions which had been put in Parliament, deputations from different Chambers of Commerce and other bodies, and to articles and letters in the public press, but principally to the effect on the telegraph revenues of the extension of telephonic communication. Taking the gross receipts for certain weeks in the present year and comparing them with the corresponding weeks in last year, they found a falling off in the telegraph revenues which they could only attribute to this cause. A return had been made some time ago from which it appeared that in a given period the increase over the whole country in telegraphic business was 108 per cent.; whereas in the same period the rate of increase in some of the busy districts, where telephonic communications existed between the large towns, was much less; between Manchester and Liverpool it was only 72, between Glasgow and Leeds 67, Leeds and Bradford 79, Leeds and Huddersfield 73, Leeds and Dewsbury 51, and Glasgow and Greenock 30. He did not think that during that period there had been any very exceptional charge of a capital nature, but there had been a considerable increase in the charge for wages. By the scheme now before the Committee it was proposed to relinquish the charge for telegraphy to the telephone companies for wires connected with local post-offices, and to allow the companies to use the houses and shops of some postmasters as call offices, which it had been represented would be regarded as a boon by the companies. The head, district, and branch offices might also be used by the companies for special purposes, and these concessions were made in view of the Post Office taking over the main lines. It was thought that considerable assistance might be afforded to the companies if the Post Office itself undertook to lay down on rental terms the main lines required to connect their exchanges together in one and the same area. The companies did not at present possess any statutory rights in regard to over-house wires, but by virtue of certain legal decisions they enjoyed practically the right of laying wires over streets under certain conditions without the consent of the local authority. What was proposed was to confer by the Bill moderate statutory powers upon them for the erection of such wires, and to place them under obligation to obtain the consent of the local authorities. The Companies had complete metallic circuit trunk lines, and the Government attached so much importance to metallic circuits that it desired that the exchange system should be so conducted.

The CHAIRMAN: Are you satisfied with the weight of the metal on the trunk lines?

WITNESS: We have reason to believe that the weight of copper is not sufficient to allow of satisfactory conversations over long distances. They proposed to have main wires from London to Belfast and to Edinburgh, and there would be spurs to Newcastle and the neighbouring towns, to Hull, Manchester, Liverpool, Sheffield, Nottingham, Derby, Leicester, and other important centres. About £400,000 would be spent in additional lines, and £600,000, he thought, would enable them to purchase the trunk lines and fill up gaps here and there.

By Sir RICHARD TEMPLE: There was no telephonic communication at present between England and Ireland, but they proposed to establish one by submarine cable.

Mr. R. HUNTER, solicitor to the Post Office, who was the next witness called, said he had prepared some amendments to meet the views of municipal corporations.

Mr. J. S. FORBES, Chairman of the National Telephone Company, said that at the present time the telephone companies conducted a great deal of their business very badly, but this was the fault of Parliament in not allowing them the necessary powers. He thought the Government should either take over the companies altogether or co-operate with them in carrying on the telephonic service. The best means of doing that would be to give the companies further powers.

The Committee then adjourned.

THURSDAY, JUNE 16TH.

After hearing further evidence (which will be given in our next issue) the Committee decided to pass the Bill substantially as it stood, and agreed to the following special report:—

REPORT.

The Bill referred to your Committee is for the purpose mainly of enabling the Treasury to raise the sum of £1,000,000 for the purchase of the trunk lines of the Telephone Companies if an arrangement contemplated between the Post Office and the Telephone Companies can be carried out; and for the erection of other trunk lines. The terms of the agreement have been laid down in a Treasury Minute presented to your House. No final arrangement, however, has been arrived at between the Post Office and the Companies. The Telephone Companies have appeared before the Committee and have urged that upon many points the terms of the arrangement should be modified in their interests. The greater number of these points are matters of detail, which, though of considerable importance, may properly form the subject of negotiation between the Companies and the Department, but on which your Committee offer no opinion. There is, however, one point of public policy of considerable importance, namely, whether the licences of the Telephone Companies originally granted for 31 years, of which about 19 are unexpired, should be extended. The Companies ask for considerable extension of their present terms. Your Committee do not recommend that the terms of these licences should be extended. With this reservation the Committee are of opinion that the responsibility for the details of an agreement with the Companies must rest with the Government, but they think that the agreement should be laid before Parliament.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY (LIMITED).

A full report of this Company's meeting on Wednesday last appeared in our issue of the 10th instant, from which it could be seen that the National Telephone Company are taking over the Western Counties and South Wales Telephone Company, and amalgamating it with their general provincial system. A memorial was sent to the Western Counties Company by the members of the Bristol Stock Exchange, suggesting another arrangement; and the following letter in reply has been addressed to the Bristol Stock Exchange by the Directors of the Western Counties Company:—

"GENTLEMEN: I am instructed by my Directors to inform you that they have carefully considered the memorial or letter addressed to them by the members of the Bristol Stock Exchange; and although the Directors think it probable that they know more of the affairs of the Company than can be known to any other association, they are nevertheless prepared to discuss all points brought under their notice.

"If the signatories of your memorial will give a firm offer to raise a sum of, say, £100,000, upon Second Preference Shares at such a rate of interest as will not exceed the earning power of this Company, my Directors will submit the proposal to the National Company, and suggest that they give to the Western Company an option of either accepting the terms of amalgamation, now under consideration, or of raising additional capital for the continuation of this Company as a separate undertaking. But, in the opinion of my Directors, it would be useless to propose the raising of capital without at the same time showing that it can be effected upon reasonable terms.—Yours truly,

(Signed) "H. F. LEWIS,
"General Manager and Secretary."

The following figures issued by the Western Counties and South Wales Telephone Company show the general business of the Company for the past seven years, and supplement the figures given in the Directors' report which appeared in our last issue:—

TELEPHONIC COMMUNICATIONS OR MESSAGES.

Year.	Trunk.	Local.	Total.	Gross Revenue.
	£	£	£	£
1885	—	1,193,334	1,193,334	8,750*
1886	—	1,942,044	1,942,044	9,914
1887	54,676	2,811,426	2,866,102	15,569
1888	284,886	3,909,856	4,194,742	21,845
1889	369,508	4,963,944	5,333,452	26,803
1890	498,320	6,045,168	6,543,488	32,837
1891	546,872	7,012,850	7,559,722	36,759

* 16 months.

BOOKS, &c., RECEIVED.

"Electric Lighting for Marine Engineers." By Sydney F. Walker. (London: Tower Publishing Company.)

"The Art of Teaching and Studying Languages." By F. Gouin. Translated from the French by Howard Swan and Victor Béhis. (London: George Philip and Son.) Price 7s. 6d.

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CORRESPONDENCE.

ELECTRIC LOCOMOTIVES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of June 3rd you were good enough to publish a correction of a passage in the new edition of my "Dynamo-Electric Machinery." I desire to supplement this by saying that the statement that the electric locomotives supplied by Messrs. Mather and Platt (Limited) for working the City and South London Railway "are now being replaced" by others is not only technically inaccurate, but altogether incorrect, and to express my regret that inconvenience and annoyance should have been caused to Messrs. Mather and Platt by such a statement. I now learn from Messrs. Mather and Platt that the rolling stock of the electric railway is about to be increased by the addition of another locomotive which is being constructed by them.—Yours, &c.,

June 14, 1892. SILVANUS P. THOMPSON.

PROF. DEWAR'S LIQUID OXYGEN EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The profoundly interesting experiments made by Prof. Dewar at his lecture last Friday at the Royal Institution have led me to think that a distinction should be drawn between the physical and chemical aspect of the change produced by the intense cooling of oxygen upon its store of energy. Prof. Dewar, dealing more particularly with the former phase, pointed out that as the velocity of the molecules of oxygen at $-200°$C. was only one-half that which they possessed at the ordinary temperature, they had of course lost three quarters of their *vis viva*; but he also touched upon the fact that their chemical affinity was greatly reduced. It is plain that to restore their former physical condition energy must be imparted to them from without; but it is not so clear that their chemical energy is really decreased—it may be only latent and incapable of exercise. In the contrary case part of the energy necessary to raise the temperature of the oxygen, that is to say, to increase the velocity of its molecules, would be used up in replacing their lost chemical energy; whence it follows that a correction, the amount of which is at present unknown, would be requisite to obtain the true value of the quantity of energy necessary merely to raise the temperature of oxygen from $-200°$C. to the ordinary temperature. Until the necessity of such correction is disproved, or its amount ascertained, the true specific heat of oxygen between these temperatures cannot be determined. The idea is capable of extension to all temperatures, in passing between which the chemical energy of a substance appears to alter. No doubt, Professor Dewar can give an authoritative explanation of what appears to be a point of some obscurity.—Yours, &c., B. B.

Westminster, June 14th, 1892.

NEWCASTLE CENTRAL-STATION COSTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent Mr. Yeaman will find all the information he asks for in our Paper *as read*, and in our reply to the discussion, which we will make as complete as possible.

You are quite right, Mr. Editor, in taking our divisor as a 30-watt lamp.

The last sentence of the last paragraph of the Paper read:—"The total cost of the unit sold (for this year to the date of the Paper) equals 2·51d., which includes all charges."—Yours, &c.,

NEWCASTLE UPON-TYNE ELECTRIC SUPPLY COMPANY (LIMITED),
R. C. JACKSON, Manager.

Pandon Dene, Newcastle upon-Tyne, June 13, 1892.

RUNNING ALTERNATORS IN PARALLEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see in your issue of the 10th inst. a letter from Mr. Charles H. Yeaman respecting the Paper read by Mr. Jackson at the Society of Electrical Engineers on the Newcastle Central Station. In the latter part of his letter he mentions the question of running alternators in parallel. If Mr. Yeaman would kindly read the article recently published in the contemporary to which he is an occasional correspondent, he will find that Deptford is not the only and by no means the most successful case of running alternators in parallel.

It has been done nightly in a most satisfactory manner, and with no hitch whatever, for over twelve months at West Brompton, which is, I believe, the only central station in England where alternators have been running in parallel for a continued period in actual work on the outside circuits.—Yours, &c., ALBERT GAY.

June 11, 1892.

WATER-POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your article in last week's *Electrician* on the above subject I observe you state that "by careful experiment the water (in cubic feet per minute) flowing over each foot of the notch has been found equal to $5·15\sqrt{h^3}$, where h = height of water over notch in inches," giving an accompanying table worked out on this basis. This, however, is only true when the notch in the board is the full width of the stream—a condition not usual in practice. When the notch is half the width of the stream the formula should be $4·8\sqrt{h^3}$, and when it is a quarter the formula is $4·59\sqrt{h^3}$, a reduction of about 7 and 11 per cent. respectively. The formula I have used is $7·72\ K\sqrt{h^3}$, where K has following values:—

Ratio of width of notch to width of stream	1	·9	·8	·7	—
K	·667	·66	·65	·61	—
Ratio do. do.	·6	·5	·4	·3	·2
K	·63	·62	·61	·6	·595

Unless the above deductions be made disappointment as to results may occur. I note also, by the way, that 66 per cent. is given as the greatest efficiency of water-wheels; I have read of overshot water-wheels giving as much as 75 per cent.—Yours, &c., W. GEIPEL.

Blackheath, June 12, 1892.

TRAIN LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your leading article on train lighting in *The Electrician* of May 27th, I should like to make, with your kind permission, some remarks concerning the accidents arising from the use of compressed gas. First allow me to call your attention to the accident which happened three years ago in Vansee (1888) near Berlin, where the passengers were burnt and badly wounded. The train was standing still in a station, when one of the carriages caught fire through the explosion of a compressed-gas reservoir. The train was full of people, and most of them were burnt before the eyes of the *employés* at the station. Five weeks ago there also happened here in Budapest an accident on the Hungarian Royal Railway, caused by the explosion of a gas reservoir, and many people were injured. Last year accidents also occurred in France.

I still hold, therefore, that the use of compressed gas is very dangerous, and it also diffuses a pungent odour, and in stormy weather the light flares.—Yours, &c., G

Budapest, June 12, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Technical Instruction Committee of the Plymouth Borough Council invite tenders for the supply and fixing of electric bells at the new Science, Art and Technical Schools, Tavistock-road, Plymouth. Specifications may be seen at the office of the Organising Secretary, at the Schools, where tenders must be delivered before 5 p.m. on Monday next, the 20th inst.

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TENDERS ACCEPTED.—Messrs. Mather and Platt's London office has secured the contract for lighting the Huddersfield Town Hall. The work consists of fitting up the building complete with 271 16-c.p., 16 32-c.p., 319 50-c.p. and 14 100-c.p. lamps, the current for which will be obtained from the new central station now being erected.

——— We learn by cable that the tender of the International Okonite Company (Limited) for wires and cables for the lighting of Melbourne has been accepted.

———The successful tenderers for the electric lighting work at Dundee (see last week's *Electrician*, p. 552) were Messrs. Willans and Robinson (Limited); the Electrical Power Storage Company (Limited); Callender's Bitumen, Telegraph and Waterproof Company (Limited); the India Rubber, Gutta Percha and Telegraph Works Company (Limited); Messrs. Siemens, Brothers and Co. (Limited); and Messrs. J. and H. Whyte and Cooper. Tenders were received from 42 firms, four of whom tendered for the entire work.

RESULT OF TENDERS.—The following tenders were received for the wiring of the Civic Buildings in Dublin. The work was divided into four sections, and contractors were asked to tender for each section separately, and for the whole :—

J. G. Statter and Co.	£1,220	0	0
Edmundsons (Limited)	1,298	15	0
Fowler, Lancaster, and Co. (Limited)	1,500	0	0
T. Scott Anderson	1,554	0	0
Laing, Wharton, and Down	1,644	0	0
Rashleigh Phipps and Dawson	1,649	0	0
Croggon and Co.	1,650	0	0
John Pearce	1,838	8	0
J. K. Fahie and Son	2,000	0	0
Electrical Engineering Company of Ireland	2,458	10	5
Berry, Harrison, and Co.	2,504	10	0

The tender of Messrs. Edmundsons (Limited) for £1,298 15s. was accepted.

MINING AND GENERAL ELECTRIC LAMP COMPANY (LIMITED).—We are asked to state, in reference to a paragraph which appeared in our issue of the 10th inst., that although this Company is in liquidation, it is only with a view to reconstruction, which is now in course of completion. In the meantime, the business is continued as heretofore.

NEW BRANCH OFFICE.—Messrs. Woodhouse and Rawson United (Limited) have recently opened a branch office, show-room, and stores at 16, Fleet-street, Dublin, their former agencies at Belfast and Cork being given up. The whole of their Irish business is concentrated in Dublin, under the management of Mr. Arthur H. M. Francis.

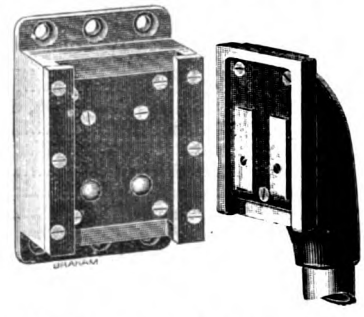
MESSRS. MORGAN WILLIAMS AND KING.—Mr. Morgan Williams, of this firm, has been instructed to act as consulting engineer to the Chiswick Local Board in carrying out their Electric Lighting Provisional Order.

MESSRS. J. B. SAUNDERS AND CO.—This firm have recently received instructions from Mr. J. H. Insoll to instal a complete electric lighting plant for Ely Court, Llandaff; a motor will also be used for pumping. The same firm have recently secured the contract for a complete installation at Velindra House, Llandaff, for Mr. P. A. V. Robinson. In the first installation a gas-engine will be used, and in the second a 7 B.H.P. Priestman oil engine.

DYNAMO BRUSHES.—Mr. James Dickson, of 48, Gray's Inn-road, London, W.C., has recently introduced the "Tieciton" Dynamo Brush, formed with strands of twisted wire plaited and cased with fine gauze. It is claimed for the new brush that there is no sparking,

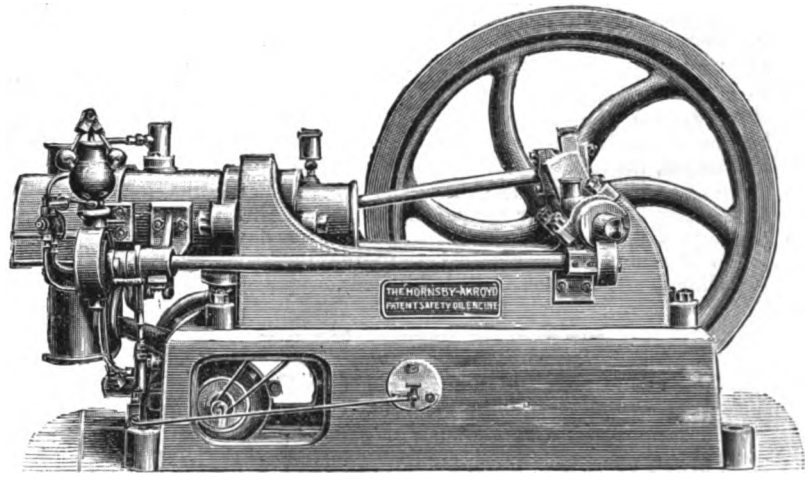
and no scoring of the commutator. The illustration above is a representation of the gauze casing lifted to show the plaited core. These brushes are already in use at a number of electricity supply companies' stations, as well as by several large engineering firms in London.

SHOP WINDOW ELECTRIC LIGHTING.—A new form of lantern for this purpose has just been put in the market by Messrs. Smeeton and Page, of 63, Queen Victoria-street, E.C. From the illustrations it will be seen that it is somewhat similar in appearance to the ordinary gas lantern, and is composed of silvered corrugated glass, instead of silver-plated copper used in gas lanterns. The corrugations in the glass add greatly to the brilliancy of the light, whereby a window may be lighted with about one-third the consumption of current of the old method by enamelled iron shades and high candle-power lamps. The reflector does not tarnish, and only requires wiping with a damp leather. The connection to the shop fascia is made by means of a detachable contact as shown below, and can be easily removed in the same manner as an ordinary gas lantern. When the lantern is removed, the front contacts fixed to the fascia may be short-circuited, without having any effect on the fuse, even if the controlling switch is on, as no current can pass until the lantern is in position, which also renders surface leakage impossible. Both the lantern and contact are very neat and effective, and are made in various sizes, and can be adapted to any window. They have been erected at the new premises of Messrs. Loewenstark and Sons, of 110 and 111, Strand, W.C., where they have proved a complete success.



ELECTRIC LAUNCHES.—The "Myionu," built by Messrs. Woodhouse and Rawson United (Limited), has recently had a new Woodhouse and Rawson motor placed in her, which enables her to run at a higher speed than formerly; and it is claimed that she is now nearly the fastest launch on the river. She has also been supplied with Epstein accumulators, which are charged at the rate of 50 amperes, enabling the charging to be done in three hours instead of six, as formerly. A new motor has also been added to the "Pioneer" by the same firm, and the steering gear has been carried forward to enable a cabin to be placed over her.

HORNSBY-AKROYD PATENT SAFETY OIL ENGINE.—We illustrate below the Hornsby-Akroyd Patent Safety Oil Engine, built by Messrs. R. Hornsby and Sons (Limited). They claim that the engine has now passed the experimental stage, and that, beyond a few minutes' heating up with a lamp before starting, no other means is



required to cause the explosions when the engine is running. Oil is used of a specific gravity of ·85, and the cost of working is claimed to be extremely small, equal to ½d. per indicated horse-power. Several of the engines will be exhibited at the Royal Agricultural Show at Warwick, including 4½, 8½, and 12 H.P. engines driving dynamos for electric lighting.

MESSRS. NEW AND MAYNE.—We are requested to state that this firm have started works at Woking for manufacturing electrical apparatus and patented specialities. These gentlemen were until lately managers to Messrs. Gill and Co. In addition to the works at Woking they have offices at Palace-chambers, Westminster, S.W.

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PIER LIGHTING.—On Thursday, June 2nd, the new Royal pier at Southampton was opened by H.R.H. the Duke of Connaught. The pier is lit throughout by the electric light, the current for which is supplied from the local supply company's station. The work has been carried out by Mr. F. Shalders, contractor, Southampton, assisted by Mr. T. Davis, under the supervision of Mr. J. G. W. Aldridge, acting as engineer to the Harbour Board.

MESSRS. MATHER AND PLATT (LIMITED).—This firm have just issued neatly-printed illustrated particulars of their latest type of alternate-current dynamos. The illustrations show a No. 2 size with a direct-driven exciter and a No. 5 size for 1,000 volts, 120 amperes, at 400 revolutions. Tables accompany the list, giving particulars and prices of machines.

THE IMPERIAL INSTITUTE.—This Institute has recently been supplied by Messrs. Archibald Smith and Stevens with 11 hydraulic lifts, pumping engines and power storage plant; the system adopted being similar to that on which the lifts for the Electric Railway are worked.

MR. JOSEPH SLATER LEWIS.—The following is the list of this gentleman's creditors:—

Allen, A., Birmingham	£10	0	3
Andrews, J., Birmingham	12	0	0
Archdale (J.) and Co., Birmingham	295	7	0
Bailey and Co., Stroud	17	3	9
Barker (T. B.) and Co., Birmingham	82	11	8
Barrows, Birmingham	15	15	1
Buck and Hickman, London	103	6	10
Callender's Bitumen, Telegraph, and Waterproof Co. (Limited), London	17	2	7
Churchill and Co. (Limited), Birmingham	31	16	0
Davies, T., Frodsham	11	11	9
General Electric Company (Limited), London	15	8	10
Greening, C., Bradford	17	16	0
Hackett (J.) and Co., Birmingham	11	13	9
Haigh (W. B.) and Co., Oldham	27	10	0
Harvey, C., Birmingham	11	9	0
Holliday, Son and Co., Birmingham	12	6	7
Johnson and Phillips, London	32	3	8
Lane, S. F., Birmingham	33	18	0
London Electric Wire Company, London	33	2	9
McCorquodale and Co., Newton-le-Willows	15	0	9
Nalder Bros. and Co., London	22	2	0
Pickles (J.) and Sons, Hebden Bridge	118	15	6
Richardson, R. J., Birmingham	47	8	6
Rosten, W. M., Acock's Green	12	15	0
Rudder and Sons, Birmingham	28	3	11
Sale, H. B., Birmingham	10	8	9
Simpson (J.) and Sons, Darlaston	41	19	5
Smith (J.) and Sons, Chester	19	1	6
Sutch (M.) and Co., Sheffield	38	17	2
Thewlis and Griffiths, Warrington	15	5	10
Tullis (J.) and Son, Birmingham	15	3	7
Waterlow's, London	31	12	0
Whiteley, W., Birmingham	13	4	6
Winter, F., London	10	13	10
and creditors under £10.			
LIABILITIES	£1,613	18	7
Fully secured creditors	1,683	15	9
ASSETS	nil.		

The bankrupt's examination will take place at the County Court, Birmingham, on the 29th inst.

BANKRUPTS' DISCHARGE.—Messrs. Allchin and Linnell, formerly trading at Northampton as electrical and general engineers, will be discharged, the former on August 5, and the latter on July 27.

JOURNALISTS ON THE THAMES.—The reporters of both Houses of Parliament held their annual dinner at Kingston on Saturday last, a pleasant feature of the outing being a trip down the Thames in an electric launch, kindly lent to the Pressmen by Messrs. Woodhouse and Rawson United (Limited).

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

May 14, 1892.

9,147. P. G. EBBUTT and J. B. VERITY. Birmingham. Improvements in or connected with electric fittings, such as fuse blocks, ceiling roses, switches, and the like.

9,148. P. G. EBBUTT and J. B. VERITY. Birmingham. Improvements in swing joints or ceiling connections, for carrying suspended electric light fittings, or combined electric light and gas fittings.

9,185. A. SHIELS. Glasgow. Improvements in couplings for electric wires.

9,192. A. J. BOULT. London. Improvements in the electrolysis of chloride and other solutions. (F. C. Bromley, France).

9,197. A. J. BOULT. London. A process of extracting zinc, iron, lead and copper from the solutions of their salts by electrolysis. (E. Liebert, Belgium).

May 16, 1892.

9,253. H. H. HALL. Liscard. Improvements in apparatus for indicating electrically words, numbers, places, or other terms.

9,282. C. D. ABEL. London. Improvements in multiple commutator apparatus for telephonic installations with metallic circuits of the system Berthon. [Société Générale des Téléphones (Réseaux Téléphoniques et Constructions Electriques), France.]

May 17, 1892.

9,300. W. MITCHELL. London. Electrically heated matrix press.

9,319. A. HENNETON. London. Improvements in or connected with anodes for the electrolytic decomposition or formation of chemical compounds.

9,331. J. W. GRANTLAND. London. Improvements in the mode of and apparatus for the transmission of currents through conduits for the propulsion electrically of railway cars, &c.

9,343. G. D. BURTON. London. Improvements in electric connectors for current converters.

9,346. C. KELLNER. London. Apparatus for the production by electrolysis of chlorine and alkalies.

9,347. C. KELLNER. London. Process for the separation of the alkali obtained by electrolytical decomposition of halogen compounds from the electrolyte which has not been decomposed.

9,356. G. D. BURTON. London. Improvements in apparatus for distributing electric currents for heating purposes.

9,362. G. D. BURTON. London. Improvements in and relating to electric metal-working apparatus.

9,365. R. LUNDELL and E. H. JOHNSON. London. Improvements in and relating to electric motors.

9,379. G. D. BURTON. London. Improvements relating to the heating and working of metal bars by electricity.

9,380. G. D. BURTON. London. Improvements in mechanism for converting electric currents, and in the method of applying the same to the working of metals.

May 18, 1892.

9,425. A. W. STEWART. Glasgow. Improvements in electrical switches.

9,435. H. NEHMER. London. Electric gong.

9,450. WOODHOUSE AND RAWSON UNITED (LIMITED). London. Improvements applicable to electric bells and other instruments. (Richard Varley, United States).

9,470. H. H. LAKE. London. Improvements in electric push es. (Carl Jörns, Germany).

May 19, 1892.

9,486. A. DICKINSON. Darlaston. Improvements in switches and crossings for the trolley wires in the over-head system of electric traction.

9,500. J. M. M. MUNRO and J. MCFARLANE. Glasgow. Improvements in electric switches.

9,519. B. RIBIERE. Liverpool. Improvements in or appertaining to decorating or illuminating by means of the electric light.

9,536. H. J. ALLISON. London. Improvements in systems of electric distribution. (Cyprien Odillon Mailloux, United States).

9,537. G. TOYE. London. Improvements in the construction of body batteries for curative purposes.

9,541. F. SCHMALHAUS. London. An improved electric accumulator or secondary battery.

9,559. A. J. THOMAS. London. A new or improved electrical sounding apparatus.

9,566. L. B. ATKINSON. London. Improvements in electric percussive tools.

9,569. C. P. SHREWSBURY and J. L. DOBELL. London. Improvements in or connected with electric batteries.

May 20, 1892.

9,612. W. LOWRIE. London. Improvements in dynamo-electric machines.

9,613. W. LOWRIE. London. Improvements in or relating to the method of maintaining or regulating the potential in electric current circuits.

9,623. J. VERNHET. London. Improvements in electric batteries.

May 21, 1892.

9,678. W. B. EDGAR and J. M. M. MUNRO. Glasgow. Improvements in electricity distribution.

May 23, 1892.

9,719. O. T. COOPER. London. Improvements in electric lamp-holders.

9,741. F. J. MORGAN and W. R. JAMES. Blaina. Morgan and James' improved "Electric miners' lamp-lighter."

9,745. E. F. FURTADO. London. Improvements in and appertaining to telephone transmitters or microphones.

9,746. E. F. FURTADO. London. Improvements for electro-telephonic receivers.

9,747. E. F. FURTADO. London. Improvements in electro-telephonic switching apparatus.

9,758. E. E. BEAUVALET and LEON C. BEAUVALET. London. Improvements relating to the regulating of electric arc lamps.

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May 24, 1892.

9,799. D. G. FitzGerald. London. Improvements in apparatus and means for the electrolysis of alkaline chlorides which may be in conjunction with earthly chlorides.

9,850. J. H. Pickup, J. Byrom, and J. Ashworth. London. Improvements in fans operated by electricity.

9,863. H. H. Lake. London. Improvements in electric signalling apparatus. (The Electric Secret Service Company, United States).

9,883. W. P. Thompson. Liverpool. Improvements in commutator brushes for dynamos or electric motors. (Charles L. Coffin, United States).

9,891. A. G. McKenna and H. T. Weed. London. Improvements in electrolytic electro-meters.

9,895. W. W. Horn. London. An improved safety attachment for overhead electric wires. (C. D. Brown, United States).

May 26, 1892.

9,906. A. V. Pittar and E. W. Beckingsale. London. Improvements in electrical switches, ceiling roses, fuses, and the like, and in the method of attaching the terminals thereof to the conductors.

9,910. C. P. Shrewsbury and J. L. Dobell. London. Improvements in the method of, and apparatus for, electrifying air, gas, or vapour for various useful purposes.

9,932. P. E. Singer. London. Improvements in electric meters.

9,933. C. J. Jones. Ipswich. The electro-plating brush.

9,941. C. H. Smeeton and H. Page. London. Improvements in electrical contacts.

9,947. R. Haddon. London. Apparatus for use in insulating joints in insulated electric conducting wires. (Alexandre Grammont, France).

9,959. T. Coad. London. Improvements in the construction of apparatus for electric search lights and signalling purposes.

9,983. W. P. Thompson. Liverpool. Improvements in the method of, and apparatus for, propelling vehicles upon railways by electricity. (Ries and Henderson, United States).

10,014. J. Melhardt. London. Improvements in incandescent electric lamps.

10,022. C. J. Grist. London. Improvements in electro-telephonic apparatus.

May 27, 1892.

10,059. E. Payne. London. Improvements connected with tubular electric conductors.

10,060. G. W. Hart. London. Electric meter for recording varying quantities of electrical currents passing in equal time periods over or along a conducting wire.

10,131. Siemens Brothers and Co. (Limited), and F. Jacob. London. Improvements in telephones.

10,133. M. M. Brandao. London. Improvements in insulating attachments for the support of overhead electrical conductors.

10,139. R. Lowenstein. London. An improvement in telephonic appliances. (C. E. Weiss, Germany).

10,143. F. H. Varley and A. Varley. London. Improvements in dynamo-electric machines and motors.

10,154. R. Holstein. London. An improved differential arc lamp.

May 28, 1892.

10,161. S. Evershed. London. Improved means of telegraphic communication with lightships.

10,173. W. S. Seaton. Glasgow. An improved form of armour for the protection of submarine cables.

10,189. H. Chitty. London. Improvements in electric motors and dynamos.

10,197. J. W. Cann and R. E. Commans. London. Improvements in electric furnaces and in the treatment of auriferous sulphides and similar refractory ores by means of the same.

10,200. C. Kellner. London. Improved process and apparatus for the electro-chemical production of bleaching agents.

10,209. G. Edwards. London. A new or improved magneto-orthopedic appliance.

May 30, 1892.

10,265. W. E. Ayrton and T. Mather. London. Improvements in electrical measuring instruments.

10,270. E. L. Berry and F. Harrison. London. Improvements in automatic electric lighting and in the apparatus therefor.

10,274. A. Sweet. London. Improvements in distribution of electricity from a central station.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

8,784. Evershed and Richards. Telegraphic signals.

9,652. Watt. Producing copper tubes by electrolysis.

10,083. Keating. Electrical cut-out.

11,625. Holmes. Electrical connections.

11,644. Timmis. Lighting trains by electricity.

11,767. Kingsbury. Telephone switchboards.

12,040. Dykes and Hird. Voltmeters.

8,806. Gravier. Dynamo-electric, &c., machines.

8,696. Huelser (vogt). Microphones.

10,094. Boys. Electrometers.

12,384. Mackay. Insulating electric wires.

12,484. Bennett. Telephonic switching apparatus.

16,931. Grassot. Electric meters.

1892.

4,017. Lake (Weston). Electric measuring instruments.

5,086. Hall. Electric block signalling apparatus.

6,961. Heil. Electrical switches.

7,044. Wood. Dynamo meters.

6,112. Lake (Sleicher and Mosher). Secondary batteries.

7,398. Hess. Telephone receivers.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades Directory and Handbook, 1892, pages 308-322, *&c., &c.*]

ELECTRIC CLOCK COMPANY (LIMITED).—This Company was registered on June 9th with a capital of £1,200, divided into 1,170 ordinary and 30 founders' shares of £1 each. The objects are to carry on, conduct, create, subsidise, or otherwise assist or participate in commercial, public, financial, engineering, mining, and industrial undertakings, works, contracts, manufactories, and businesses; to carry on any business which may be considered advisable or conducive to the interests of the Company; and in particular, to enter into and carry into effect, with or without modification, an agreement to be made between Leon Pope, of 98, Richmond-road, Barnsbury, London, N., electrician, of the one part and the Company of the other part.

CHAMBERLAIN AND HOOKHAM (LIMITED).—The annual return of this Company, made up to April 26th, was filed on May 11th. The Company was registered on April 14, 1883, with a capital of £100,000, divided into 5,000 "A" and 5,000 "B" shares of £10 each. At the time of making up 1,000 "A" and 5,000 "B" shares had been taken up, of which the "B" shares had been issued as fully paid. Upon the "A" shares a call of £3. 10s. per share had been made, resulting in the payment of £3,500.

MARSHALL, SONS, AND CO. (LIMITED).—The annual return of this Company, made up to May 13th, was filed on the 19th. The Company was registered on August 21, 1862, with a capital of £20,000, in £20 shares. After several increases had been made in the capital, the capital was raised in March, 1891, to £400,000, in £20 shares; and, by a notice filed July 23, 1891, the shares, Nos. 1 to 10,000 inclusive, were converted into £200,000 stock. At the time of making-up, 2,000 shares, in addition to the £200,000 stock, had been taken up, and a call of £1 per share made, resulting in the payment of £2,000.

RANSOMES, SIMS AND JEFFERIES (LIMITED).—The annual return of this Company, made up to April 28th, was filed on May 3rd. The Company was originally constituted by Articles of Association dated May 1, 1884, and was registered on May 12, 1884, as a limited company, with a capital of £500,000, in £100 shares. At the time of making up, 3,075 shares had been taken up. Upon 2,185 of these the full amount had been called, while upon the remaining 890 shares £50 per share had been called, resulting in the payment of £263,000

SOUTHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, made up to June 6th, was filed on the 11th. Out of a nominal capital of £30,000, divided into 4,000 preference and 2,000 ordinary shares of £5 each, 10 preference and 688 ordinary shares have been taken up. Upon these the full amount has been called, resulting in the payment of £3,364, and leaving £126 in arrears.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 31st, was filed on June 8th. The Company was registered on January 9, 1877, with a capital of £2,445,630, in £10 shares. The capital is £2,445,630, divided into 200,000 ordinary, 34,563 first preference, and 10,000 second preference shares, of £10 each. At the time of making up, 83,321 ordinary, 34,563 first preference, and 4,669 second preference shares had been taken up, the full amount called, and all calls (£1,275,530) paid.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 12th were £745, as against £860 for the corresponding period of last year, being a decrease of £115. The total receipts to date, from January 1st last, amount to £18,936, against £17,780 in the corresponding period of 1891, being an increase of £1,156.

DIVIDENDS DUE.—*June 24*: Brazilian Submarine Telegraph Company (Limited), Interim, 3s. per share for quarter ended 31st March, nett. Books closed 17th to 23rd June.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—The Stock Exchange Committee have ordered £98,400 additional Four per

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Cent. Mortgage Debentures of this Company to be quoted in the Official List. This Company notify that the Coupons due July 1st next on their Five per Cent. Mortgage Debentures, will be paid on and after that date at the banking house of Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—Application has been made to the Stock Exchange Committee to allow £104,900 Six per Cent. First Mortgage Debentures to be quoted in the Official List.

GREENWOOD AND BATLEY (LIMITED).—At the fourth ordinary general meeting, held on Friday under the presidency of Mr. Arthur Greenwood, the Chairman regretted that the Directors could not recommend the payment of a dividend to the ordinary shareholders; although he thought that, looking at the state of trade generally, it was matter for congratulation that the Company was not in a worse position. The report, which recommended a dividend of 7 per cent. on the preference shares, was carried.

SOCIETA GENERALE ITALIANA DI ELETTRICITA (SISTEMA EDISON).—Last year's working resulted in a profit of £7,934, and a dividend of 6½ per cent. has been declared.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 10, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,622.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	L Dividend.	Name.	Previous Week's Price, June 8.		Price Wednesday, June 15.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 15.	
			TELEGRAPHS.					£ s. d.		Highest.	Lowest.
£1,300,980	Stock	12/6	Anglo-American	48	49	48	49	5 12 3	Jan., Apr., July, Oct.	48	..
£2,849,510	Stock	25/0	Do. Preferred	88½	89½	88	89	5 18 0	" "	88½	88½
£2,849,510	Stock	5/0	Do. Deferred	11¼	11¾	10¾	11¼	..	" "	11	10 7/8
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101	104	101	104	3 16 11	January and July ..	101½	..
130,000	£10	3/0	Brazilian Submarine	10¼	10⅝	10¼	10½	7 8 10	Mar., June, Oct., Dec.	10⅝	10½
£68,200	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	105	109	105	109	4 11 9	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	158	163	155	160	4 7 6	Jan., Apr., July, Oct.	158½	..
16,000	10	8/0	Cuba Submarine	11	12	11	12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3¼	3⅜	3¼	3⅜	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅛	11⅜	11⅛	11⅜	5 19 2	Jan., Apr., July, Oct.	11⅜	11⅛
400,000	10	2/6	Eastern	14⅜	15	14⅜	15	4 6 8	" "	14⅛	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15¼	15⅜	15¼	15⅜	3 16 2	" "	..	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108	111	108	111	3 12 1	May and November	109¼	109½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 11 9	February & August	..	..
250,000	10	6/6	Eastern Extension	15	15½	15	15½	4 11 10	Jan., Apr., July, Oct.	15⅜	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 1	February & August	110	109
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb.,1900	102	105	102	105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	103	102½
180,227	10	2/6	Globe Telegraph and Trust	10½	10½	10½	10½	5 0 0	Jan., Apr., July, Oct.	10½	10½
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 18 1	" "	15⅝	15½
150,000	10	7/2	Great Northern	18¾	19¼	18¾	19¼	4 9 2	Jan., April, and July	19	18⅞
£120,000	100	5%	Do. 5 per Cent. Debentures, 1883	108	109	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	40	42	40	42	5 19 1	May and November	41½	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	5 14 4	" "	..	..
£103,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's xd	7	8	6½	7½	5 6 5	April and October..	7	..
3,381	£100 Cert.	£1¼	Submarine Cables Trust 6%	115	120	116	120	5 0 0	" "	117	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	100½	..
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	5 11 1	January and July ..	3⅞	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	104	108	7 8 2	June and December	104½	..
88,321	10	6d.	West India and Panama	1¼	1½	1¼	1½	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9¾	10¼	9¾	10¼	5 17 1	May and November	9¾	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8	9	8	9	6 13 4	" "	..	..
67,007	15	6/0	Western and Brazilian	9¼	9⅜	9¼	9⅜	6 3 1	" "	9 3/8	9¼
30,364	7½	1/3	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	6¾	..
30,364	7½	4/6	Do. 5 per Cent. Deferred	3¼	3½	3	3½	..	" "	3½	3¼
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105	108	105	108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105	108	105	108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	115	119	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance xd	⅛	⅜	⅛	⅜	6 10 10	May and November	..	..
x20,000	£1	4⅛d.	Oriental (11s. paid)	3/16	5/16	3/16	5/16	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅜	4⅝	4⅜	4⅝	6 3 1	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½	13¾	13½	13¾	4 7 3	" "	13⅜	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12⅛	13	12⅛	13	4 12 4	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	108	110	108	110	4 1 10	January and July ..	109¼	108¾
58,000	5	1/0	United River Plate	1½	2¼	1½	2¼	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7¾	8¼	9¾	10¼	..	—	10⅛	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	2½	3½	..	..	..	—	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	..	5	5½	..	—	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5½	6	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/8	3 9/16	3 7/8	3 9/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16	5 3/16	5 1/16	5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	⅜	1	⅜	1½	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	7½	8	7½	7¾	..	—	7⅝	7½
6,318	10	..	Notting Hill Electric Lighting (fully paid) .. x new	4	5	4	5	—	—	..	—
18,680	£5	5/0	St. James' and Pall Mall	8½	9	8½	9	—	—	..	..
7,900	£5	7%	Do. 7% Preference	8	8½	8	8½	..	—	8 1/8	8
42,853	5	..	Westminster Electric Supply (fully paid)	6½	7	6¼	6¾	..	—	6⅝	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	2⅞	3⅛	2⅞	3⅛	..	—	3 1/8	3
69,996	2	6%	Do. 6 per Cent. Preference	2	2¼	2	2¼	5 2 7	—	2¼	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	5¾	5¼	5¾	5 16 8	January and July ..	5 1/16	..
17,139	5	17½	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	5½	6	5½	6	..	—	5⅞	5¾
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅞	2⅜	2⅝	—	—	2⅝	2 7/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½	20½	19½	20½	6 1 11	February & August	20½	19⅞
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	104	106	4 4 11	March & September	104	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½	4½	3½	4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛	⅜	⅛	⅜	..	..	..	..
78,949	5	2/9⅝	Swan United (£3. 10s. paid)	3½	4	3½	4	9 13 0	May and November	3 7/16	3½
36,250	12	36/0	Telegraph Construction and Maintenance	44	46	44	46	5 4 9	March and July.....	45¼	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103	106	103	106	4 14 4	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅛	⅜	..	..	..	—	..	—
—	£5	8%	Do. Preference (fully paid)	2½	3	..	..	..	—	—	—
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2½	3½	2½	3½	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

The letter which we print in this issue from Dr. E. Hopkinson gives some interesting information about the electrical working of the City and South London Railway; and the important statement that the weight of the carriages was increased from 4½ tons to 7 tons fully explains the over-straining, delays, and wear and tear which have been experienced. The fact that the working expenses per train mile turned out to be 25 per cent. less than the amount guaranteed, although the weight of the trains had been increased 40 per cent., speaks very highly both for the design and the management. The comparison of the yearly mileage of the Metropolitan District locomotives with those which have been built under Dr. Hopkinson's supervision is another interesting point, which, together with the fact that the mileage for the half-year on the City and South London Railway was only 188,666 against a proposed mileage of 384,000, shows what a great success may be expected from a line in which all these matters have been carefully considered and arranged, not only with careful calculation, but with the experience of actual working.

Dr. J. Hopkinson's transformer tests, a report of which we publish in this issue, are worthy of close study, as the method adopted, although lengthy, and somewhat laborious to carry out, is one which is susceptible of great accuracy. The main idea of the method is to directly measure the losses occurring in the transformer under different loads, and to deduce the efficiency by comparing these losses with the energy transformed. In this respect there is a close similarity to Dr. Hopkinson's well-known method of finding the efficiency of a dynamo from tests on a combination of dynamo and motor. The calorimeter method of measuring transformer efficiencies has the same characteristics, but the great difficulty of getting accurate results from heat measurements practically neutralises the advantages which this method would otherwise possess. The measurements required in Dr. Hopkinson's method are of a much more certain character, and the contact apparatus needed for the tests has been so often used for alternate-current researches that it should be regarded as a necessary part of the equipment of a good electrical laboratory.

The particulars of the tests have only just come to hand, so that it is impossible to adequately criticise the results. The efficiencies of 97 per cent. at full load and of 85 per cent. at one quarter load are very satisfactory. The numbers given show that the all-day efficiency of the transformer is as much as 92 per cent., assuming that the converter is worked for six hours at full load, and for 18 hours on open circuit. This high result will probably surprise the advocates of low potential systems of distribution. With regard to the losses occurring in the transformer, it seems remarkable that the eddy current losses should be so high. According to the tests the waste in hysteresis is one per cent., and that in eddy currents is 0·75 per cent. of the full load. The ratio of the latter to the former seems unnecessarily large.

The only reply that we can offer to the inquiry of Mr. Ferranti, which will be found in our correspondence columns, is, that the "committee of experts" of the Crystal Palace Exhibition is little else than a farce, and we believe that this is admitted by the majority of the members. The testing of the meters would have been one of the most simple jobs; and the only excuse for the committee and for the jury is that their nomination was thrust upon them by the promoters of the Exhibition, probably with the view of getting the use of their names. The Exhibition has been a splendid success without any assistance from these gentlemen, who have so generously consented to do nothing.

The internal or lost volts of a dynamo do not, as a rule, concern electrical engineers. They are taken, together with the demagnetising turns of the armature, as something to be overcome by the series-winding in a compound dynamo, and they enter into the calculations where dynamos are designed by calculation. These volts, together with the difference of potential between the terminals, make up the whole electromotive force of the dynamo, but they do not form part of the difference of potential. In an endless ring of a hundred cells, each having an electromotive force, or a difference of potential of one volt, it is impossible to find at any two points a difference of potential of one hundred volts; but an electromotive force of one hundred volts is present. In our description of the electric lighting at Oxford in another column we allude to the slowing down of a dynamotor before cutting out, to reduce the current to nothing. Supposing a constant pressure of one hundred volts is maintained on a circuit, and three dynamos in parallel are delivering, say, one hundred amperes each into the circuit; the difference of potential at the terminals of the dynamos is one hundred volts. If one of them be slowed down so as to

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contribute no current to the circuit, it cannot be said to run at a lower voltage, for the volts at the terminals are still one hundred; the same as before. The difference of potential has not changed, but the electromotive force has been altered. The difference consists in what may roughly be called the fall of volts over the armature, though no such fall can be measured by any voltmeter or electrometer. As a matter of fact, it is very difficult to make several dynamos share a load evenly, especially if driven by separate engines, since this difference is so small.

The problem of the connection between ether and matter is one which excites a great interest among theorists, but its solution seems at present beyond the reach of experiment. In this respect it resembles the problem of determining the seat of electromotive force in a voltaic cell, or of determining whether the lines of force rotate with a magnet when revolving about its axis. In each case it seems difficult to devise any crucial experiment to decide between two rival theories. It will be seen that most of the experiments referred to in Dr. Lodge's able summary, which he recently gave to the Physical Society, and which we print in abstract in another column, yielded only negative results, so that any conclusion drawn from them is doubtful.

The whole subject is very abstruse, yet it is closely concerned with much that is of interest to practical electricians. For instance, in the case of an armature revolving between the field-magnets of a dynamo, everyone has a clear idea of the mechanical force exerted on the conductors which convey the currents. We have also definite notions of the currents induced in the conductors by their motion across lines of force. The mechanical power used to turn the armature is transformed to the electrical power possessed by the currents. Of the process of transference we, however, are quite ignorant. From one point of view we look upon the armature conductors merely as a material substance pulled round by mechanical force; but from the other standpoint we regard the wires merely as paths, and have no occasion to think of the matter of which these conductors are composed. The mechanical force exerted depends on the current through the wire; but this force is exerted, not on the electric current, but on the wire itself. In the connection between ether and matter, when discovered, will perhaps be found the solution of the great problem of gravitation. The law of attraction according to the inverse square of the distance is already explained for electrical and magnetic phenomena by the action of contiguous particles of ether; and it seems most probable that the solution of these other difficult problems will ultimately be found in researches of an electrical nature.

At a meeting of the Common Council at the Guildhall on the 16th inst., a report was presented on the position of the Corporation as regards the City and Guilds of London Institute, and it was recommended that no further contribution should be made for a year or two. The refusal of the Corporation of the City of London to support the City and Guilds of London Institute will surprise many of those who are unacquainted with the details of the management of this foundation. The fees of the students are manifestly inadequate to meet the expenses, and it seems that it was never intended from the first that either of the branches should be self-supporting. The City of London has contributed less even than one of the Guilds, viz., the Drapers', and has lately been taking less and less interest in the Institute, which, therefore, seems to stand in need of a new title.

On the occasion of the meeting which was held at the Mansion House on March 11th to consider the Chicago Exhibition, those present were given to understand that foreign manufacturers would be allowed to label their wares with the selling prices inclusive and exclusive of duty. Upon the very same day, however, that this powerful inducement to exhibit was being dangled before the Mansion House gathering, Mr. Geo. R. Davis, Director-General of the Exhibition, was penning the following letter to Mr. William F. Wharton, Acting Secretary of State:—

Sir,—I have the honour to acknowledge the receipt of your letter of March 2nd, enclosing a copy of a despatch from the United States Consul at Rheims, making inquiry in regard to price marks which foreign manufacturers of woollen goods may be allowed to place upon their exhibit at the World's Columbian Exposition. In reply to the inquiries of the Consul I have the honour to advise the department that foreign manufacturers, under the regulations heretofore adopted for the management of the Exposition, will be allowed to place upon their exhibits cards bearing their statement of the cost of manufacturing any articles which they may have in their display, and upon the same or other cards they may state the net price which they desire to place upon the said articles for sale in the City of Chicago. Exhibitors who desire to take advantage of this privilege will be strictly required to sell the articles whose prices are so stated to any purchaser who may tender payment for the same, the articles themselves not being deliverable until the close of the Exposition. It would be obviously impracticable to permit exhibitors of foreign manufactures to place upon their wares prices which they might undertake to accept for the same provided no tariff law were in force in the United States.

Just so; exactly what we predicted. We thoroughly agree with the correspondent of our contemporary the *Engineer*, who is of opinion that "very definite information is required on the subject," and advises exhibitors either to insist upon the *understanding* of March last being honourably carried out, or to refrain from exhibiting.

Personal.—Mr. Denny Lane has been elected President of the Incorporated Gas Institute.

Taunton.—At a Town Council meeting last week it was resolved, by 10 votes to 5, to purchase the Taunton Electric Light Works, at a cost of £9,300.

Pretoria (Transvaal).—The Johannesburg *Star* states that the streets of Pretoria were experimentally lighted up for the first time by electricity on May 21st.

Electric Launches in Germany.—The Allgemeine Elektricitäts Gesellschaft is about to build a number of electric launches to run on the Wannsee, near Berlin.

Burnley.—On Tuesday Mr. Arnold conducted a Local Government Board inquiry relating to the application of the Council for permission to borrow £29,000 for a scheme of electric lighting.

The Niagara Falls Power Plant.—Two 5,000 H.P. turbines have been ordered by the Cataract Construction Company from Fœsch and Ficcard, of Geneva, Switzerland, for the Niagara Falls power plant.

Interurban Telephony.—Dunkerque and Marseilles, which are some 550 miles apart, will shortly be placed in telephonic communication. St. Petersburg and Moscow (409 miles) are to be connected by telephone this summer.

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Obituary.—The death of Mr. George F. Green from intermittent fever is announced. Mr. Green was 60 years of age, and is reputed to have invented the electric street car. He was working on a new electric car at the time of his death.

Cable Restorations:—

	Interrupted	Restored
Bissao-Bolama	April 23, 1892.	June 21, 1892.

All cable routes are at time of going to press in good working order.

Lightning.—During a recent storm at Chicago some 50 persons took refuge in the corridors of the Grant Monument, Lincoln Park. Shortly afterwards the lightning struck the monument. Two men and one woman were killed on the spot, and other persons seriously injured.

Islington.—At the last meeting of the Islington Vestry the Electric Lighting Committee presented a recommendation that a Provisional Order authorising the Vestry to supply electricity should be applied for. The Committee have come to the conclusion that it is possible to give the supply at 5d. per unit.

Cologne Central Station.—On Friday, the 17th inst., this central station was visited by a deputation from the Leicester Gas Committee, who were present during the operation of switching a 150-H.P. alternator into parallel with a 500-H.P. machine, an operation at which Mr. Nikola Tesla was also present.

Société Internationale des Electriciens.—Members of this Society, of which Mr. R. Aylmer, M.Inst.C.E., is hon. secretary and treasurer in this country, are requested to note that the Society's office has been moved from 42, Parliament-street, to 47, Victoria-street, S.W., and that the registered telegraphic address is "Leclanché, London."

Society of Arts.—Among the silver medals awarded this session by the Council are the following:—Prof. Silvanus P. Thompson, F.R.S., for his Paper on "Measurement of Lenses;" Mr. G. H. Robertson, F.C.S., for his Paper on "Secondary Batteries;" Captain W. de W. Abney, C.B., F.R.S., for his Paper on "Colour Blindness."

Mean Spherical Candle-power.—It has been pointed out by Mr. G. W. Patterson, Jun., of the University of Michigan, that the method for finding mean spherical candle-power, given on page 13 (*The Electrician*, May 6, 1892), is erroneous. The method of M. Rousseau is given in Palaz's *Photometrie Industrielle*, page 16, as well as in Gerard's *Leçons*, Vol. II., p. 298.

Ballarat School of Mines.—A department of electrical engineering has recently been added to this institution. It is under the direction of Mr. J. A. Dawson, who has wired a portion of the school and installed the electric light, the current being furnished by a Weston compound-wound dynamo in the laboratory. The course of instruction for this department extends over two years.

The Proposed Mont Blanc Observatory.—According to *La Lumière Electrique*, M. Janssen is about to renew his efforts to get an observatory constructed on Mont Blanc. The structures erected before the winter set in have not been injured. An observatory of wood is to be constructed at Chamounix, and transported piece by piece to the summit. Atmospheric electricity observations will be made.

The Electric Railway Bills.—The Baker-street and Waterloo and Great Northern and City Electric Railway Bills have been referred to a Committee of the House of Lords, consisting of the Marquis of Waterford (Chairman), the Marquis of Breadalbane, Lord Norton, Lord Wimborne, and Lord Magheramorne. The Committee held its first sitting yesterday (Thursday), and a report of the proceedings will be found in our present issue.

Military Projectors.—The French military authorities have recently been experimentally verifying the extraordinary immunity from rifle fire enjoyed by powerful projectors, a fact first brought out in this country some years ago. At the camp at Satory a military projector was set up on the rifle range, and after 175 rounds had been fired at it was practically uninjured. Only one bullet had hit it, and this had merely pierced the case.

Yarmouth.—At the last meeting of the Town Council it was agreed that Messrs. Crompton and Co., Messrs. J. E. H. Gordon and Co., Messrs. Woodhouse and Rawson, Messrs. Hammond and Co., the Planet Electrical Engineering Company, and the Brush Company should be asked to submit schemes with estimates; and that the Electric Lighting Committee should be authorised to employ a consulting engineer to advise them on the specifications and tenders.

Imperial Telegraphic Communication.—At the second Congress of the Chambers of Commerce of the Empire, which will be held at the end of the present month, Sir George Baden Powell will move "That, in the opinion of this Congress, the extension of direct telegraphic communication between the component parts of the British Empire will facilitate defence, promote trade and investments, emphasise community of interests, and generally stimulate the development and consolidation of the Empire."

The Central London Railway.—The Select Committee of the House of Commons, to whom was referred all the London electric railway schemes, having declined to consider in the present Parliament the scheme promoted by the Central London Railway Company to extend their authorised railway from the Mansion House to Liverpool-street Station, the promoters have come to an arrangement with the whole of the opponents, whereby no further opposition will be offered to this extension in either House.

The Société d'Aluminium de Neuhausen.—According to the report of this concern the gross profits of the past twelve months amounted to over £12,000, and the net profits to £6,650, while the market price of aluminium was reduced from 1,900fr. to 625fr. per 100 kilogrammes (7s. to 2s. 6d. per lb.). At the beginning of last year £2,200 of aluminium was being sold per month, while at the end of the year the figure was £5,200. The Neuhausen works can turn out 20 tons of aluminium a month if necessary.

The Paris Electricity Supply Companies.—A committee of the Paris municipality has decided to recommend the prolongation of the electric lighting concessions from 18 to 43 years; the companies, in return for this prolongation, to reduce the maximum price of the hectowatt-hour from 15 to 13 centimes. If, however, the municipality should decide on the purchase of the electric lighting concerns compensation will only be accorded on the basis of the original eighteen-year grant. The price of the plant itself to be fixed by an expert.

Worcester.—At the last meeting of the Town Council it was decided, after considerable discussion, by 28 votes to 10, to accept the Brush Company's tender, subject to obtaining the sanction of the Local Government Board to the requisite loan, and subject to a report from the Watch Committee as to (1) whether provision should be made for steam power only, or steam power and water power combined; (2) whether provision should be made for street lighting. The revised Brush tender amounts to £15,980, and with street lighting will be £22,680.

Proposed Electric Lighting of the Thames Embankment.—At the last meeting of the London County Council the Highways Committee presented a report on the proposal to substitute electricity for gas on the Thames Embankment. They recommended that it be referred to the Highways Committee to carry out, at a cost not exceeding £10,000, an electric installation, with the necessary plant, for the lighting of the carriage ways, footways, and parapet wall of the Victoria Embankment. The consideration of the matter was adjourned for a week.

Exeter.—At the last meeting of the Town Council the Mayor said that he regretted the Council had not been able to see their way to adopt the electric light. But he thought they could not now afford an extra outlay of £392. 17s. 4d. for a light which might not suit the streets of the city. Several councillors objected to a seven years' contract with the Gas Company, and ultimately it was decided that unless the Gas Company were prepared to contract on the same terms for three or five years the Council would give notice to terminate their contract at Michaelmas next.

The Western Union and Bell Telephone Companies.—The general public, says the *Western Electrician*, will derive some

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satisfaction from the fact that the Bell Telephone Company and the Western Union Telegraph Company are engaged in a legal warfare over the disposition of profits of the former Company. It seems to be the general impression that it is a good thing to get up a fight between these powerful corporations, even though the public is not directly benefited thereby. The idea of making one or both of these great corporations yield a part of the enormous revenues derived from the business has a peculiar charm for the average American.

Electrical Communication with Lightships and Rock Lighthouses.—The Royal Commission appointed to inquire into the question of telegraphic communication with the lighthouses and light vessels around the coasts of the United Kingdom held a preliminary meeting on Saturday last, at 21, Northumberland-avenue, under the presidency of the Earl of Mount Edgcumbe. The other Commissioners are—Sir E. Birkbeck, M.P., Admiral Sir F. L. M'Clintock, Vice-Admiral Sir George Nares, Mr. J. C. Lamb, Mr. R. C. Munro-Ferguson, M.P., Mr. Edward Graves, Mr. J. A. Kempe, Mr. H. L. Mulholland, M.P., and Mr. Garnham Roper, secretary. The Commission will not meet again until the end of July.

Platinum.—Canadian platinum ore, as a commercial article, says the *Engineering and Mining Journal*, is entirely the product of British Columbia. In association with alluvial gold it has been met with in a number of the streams of that province. Placer mining in the Tulameen district yields both gold and platinum, the latter being found, like the gold, in grains and small nuggets. A notable quantity of platinum has already been obtained from this district. One firm in the United States claims to have purchased within the last year or two fully 2,000oz. of British Columbia platinum, and it is well known that a portion of the yield of this district has found its way to the London market. An increase of output may be expected, as the Tulameen Hydraulic and Improvement Company has made preparations to begin hydraulic mining on a large scale.

Electrical Transmission of Power in Switzerland.—An important electrical plant, says the Zürich correspondent of *Industries*, is about to be erected for the transmission of power at Albino. The waters of the Serio are to be stored by a dam 374ft. long, and of a height of 8·2ft. The water will then enter into a canal 2,624ft. long, and will be conveyed by a conduit, 1,805ft. long and 6·9ft. diameter, to the turbines at Cene, a total fall of 49ft. being obtained. There will be three turbines, each of 325 H.P., made by Messrs. Escher, Wyss, and Co. The armatures of the 1,500-volt continuous-current dynamos are placed on the vertical shafts of the turbines. The power will be transmitted a distance of about two miles to the spinning and weaving establishment of Honegger, Spoerry, and Co. The electric plant for this installation is being furnished by the Oerlikon Works.

Mr. Samuel Varley.—A meeting, attended by Messrs. R. E. Crompton, T. E. Gatehouse, W. A. Gorman, Prof. D. E. Hughes, Mr. T. Parker, Major Flood Page, Messrs. A. Stroh and J. W. Swan, was recently held at the rooms of the Institution of Electrical Engineers, for the purpose of discussing the best method of recognising the great services of Mr. Samuel Varley to the electrical industry. The meeting was unanimously of opinion that the services of Mr. Samuel Varley to the electrical industry deserved substantial recognition, and that everyone interested in electrical engineering should be invited to join the Committee for the purpose of discussing the best form that this recognition should take, and that a draft circular should be prepared ready for submission to a meeting of the Institution of Electrical Engineers at 28, Victoria-street, on Friday, July 1st, at 4 o'clock.

London County Council Overhead Wires Bye-Laws.—On Monday a conference took place between the officials of the Board of Trade and the representatives of the London County Council, the Commissioners of Sewers, the Telephone Companies, and several of the Vestries of the metropolis, with reference to the London County Council bye-laws, made in pursuance of the London Overhead Wires Act, of 1891 (see *The Electrician*, Vol. XXVIII., p. 149). The Board of Trade was represented by Sir Courtenay Boyle, Mr. Gray (Counsel for the Board), Sir Thomas Blomefield, Major Cardew, and Mr. W. H. Preece. Among the parties who had objections were Mr. Meadows White, Q.C., Mr. Bloxland, Mr. Hertslet and Sir Benjamin Baker, for the County Council; and Messrs. J. S. Forbes, Winterbotham, Wallace, Wilkins, Gaine, Baylis, and Col. Heywood represented other parties. The rules were gone through *seriatim*, and at the close of a five hours' sitting Sir Courtenay Boyle intimated that the Board of Trade would communicate to the County Council its approval or otherwise.

Strike of Spanish Telegraphists.—The telegraphists throughout Spain have struck work on account of the amalgamation of the telegraph and postal services. The telegraph staff have to pass an examination before being appointed, and they have never taken any part in political matters, whereas the post-office officials in most cases owe their appointments to political influence. At Madrid the Government has replaced the officials on strike by military operators, but telegraphic communication with the provinces is practically suspended. For instance, there are 21 repetitions between Bilbao and Madrid. A Reuter's telegram dated Bilbao, June 22, says:—The strike of telegraph operators in this country is complete. There is not a single line working in the interior of Spain, and the only means of communication with foreign countries is by the cables from Bilbao, Barcelona, Vigo, and Lisbon. There seems a probability of the strikers establishing their claims and forcing the Government to concede their terms. Nearly 2,800 operators are idle, the majority being present in the telegraph offices while refusing to touch their instruments.

Electricity in Warfare.—In a recent article in the *St. James's Gazette* a "Military Optimist" writes:—"Important experiments have been made with the electric search light as an aid to night operations; while the telegraph battalion has done some thoroughly good and novel things. That was no insignificant feat performed the other night, when an extensive cable was laid rapidly over the roughest possible ground (in the dark, mind!) and enabled the lieutenant-general not only to find a lost brigade, but to control the simultaneous advance and attack of three separated brigades on an earthwork at midnight. The telegraph, in fact, rendered a most difficult and doubtful operation comparatively easy and certain. At the manœuvres last autumn, too, a highly useful attempt was made to produce on a map at head quarters a plan of battle step by step as it progressed many miles away, by means of reports wired from the field. The attempt did not succeed, because the maps available were not on a sufficient scale; but the feasibility of the plan was demonstrated, while its value to a general directing operations over a wide field is obvious enough. With large-scale maps, a balloon, and increased observing staff, it should be made a most important aid to the strategist and the tactician."

Electrical Engineering at University College.—For some time past the Council of University College have been desirous of extending the provision made for teaching mechanical and electrical engineering. The present provision for teaching these subjects is, however, no longer adequate. The Council have therefore resolved to build better and more commodious engineering and electrical laboratories and lecture rooms. They have accordingly instructed their architect, Prof. Roger Smith, to prepare plans and specifications for a new technical laboratory. These designs have been very carefully prepared in accordance with the views of Profs. T. H. Beare and J. A. Fleming. To fit up that part of the proposed laboratory specially set apart for electrical engineering, Prof. Fleming asks for the modest sum of £2,010. The Council do not at present see their way to incur this additional expenditure over and above the cost of the buildings, and yet it is absolutely essential to the completion of the project. The Council have, therefore, recommended this part of the proposed work to the notice and liberality of those who may be disposed to help. It is to be hoped that this good work will commend itself especially to past students and friends of University College, and that the necessary help will be forthcoming. Donations should be sent to the Secretary of University College, London, marked "Electrical Apparatus Fund."

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ELECTROMAGNETIC THEORY.—XXXI.

BY OLIVER HEAVISIDE.

(*Continued from page 139.*)

§145. The elastic solid with two elastic constants (k and n) has not been found sufficiently elastic to supply a thoroughly satisfactory analogy with Maxwell's ether, though partial analogies may readily be found. Other kinds of elasticity than resistance to compression and distortion, and other kinds of resistance than elastic resistance, present themselves to the consideration of searchers for analogies between the propagation of disturbances in Maxwell's ether and in the brutally simple elastic solid of theory, which is, however, known to fairly represent real solids within a certain range.

There are four distinct ideas involved in the displacement of a small portion of matter, viz., the translation as a whole, the rotation as a whole, the change of size, and the change of shape. These separate themselves from one another naturally. As regards the mere translational motion, if it be only inertially resisted, we have the equation of motion

$$\mathbf{f}+\mathbf{F}=\rho\frac{\delta\mathbf{q}}{\delta t}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (306)$$

where ρ is the density, $\mathbf{q}$ the velocity, $\mathbf{f}$ impressed force (per unit volume), $\mathbf{F}$ the force arising from the stress associated with the strain (including rotation, distortion, and expansion), and $\delta/\delta t$ the time-differentiator for moving matter. This equation is constructed on simple Newtonian principles. We may, however, wish to have elastic and frictional resistance to translation, as well as inertial resistance. Then generalize the above to

$$\mathbf{f}+\mathbf{F}=\left(\rho_0+\rho_1\frac{d}{dt}+\rho_2\frac{d^2}{dt^2}\right)\mathbf{G}, \quad . \quad . \quad . \quad (307)$$

where $\mathbf{G}$ is the displacement, when small departures from equilibrium are concerned. Here ρ_2 is the ρ of (306), ρ_1 is the frictionality (Lord Kelvin's word for coefficient of friction), and ρ_0 is an elastic constant. The displacement from equilibrium calls into action a back force $\rho_0\mathbf{G}$ proportional to the displacement, with storage of potential energy; a force $\rho_1\dot{\mathbf{G}}$ proportional to the velocity, with waste of energy; and a force $\rho_2\ddot{\mathbf{G}}$ proportional to the acceleration, with associated kinetic energy. The potential energy is $\frac{1}{2}\rho_0\mathbf{G}^2$, the rate of waste $\rho_1\dot{\mathbf{G}}^2$, and the kinetic energy $\frac{1}{2}\rho_2\dot{\mathbf{G}}^2$.

As regards the force $\mathbf{F}$, this is given by (284), when the stress is irrotational, and the elastic constants are n and k. But, in general, we may proceed thus. First separate the rotation from the strain vector. We have

$$\begin{aligned}\mathbf{N}\nabla.\mathbf{G}&=\tfrac{1}{2}(\mathbf{N}\nabla.\mathbf{G}+\nabla.\mathbf{N}\mathbf{G})+\tfrac{1}{2}(\mathbf{N}\nabla.\mathbf{G}-\nabla.\mathbf{N}\mathbf{G})\\&=\mathbf{p}_\mathbf{N}-\tfrac{1}{2}\mathrm{V}\mathbf{N}\operatorname{curl}\mathbf{G}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (308)\end{aligned}$$

Here $\mathbf{N}\nabla.\mathbf{G}$ means the variation of displacement per unit distance along $\mathbf{N}$, which is any unit vector, so that by giving $\mathbf{N}$ all directions (practically only three) the complete state of strain is known. This strain vector is above analysed into the strain $\mathbf{p}_\mathbf{N}$ without rotation, and the second part depending upon rotation. But $\mathbf{p}_\mathbf{N}$ includes the expansion, as well as the distortion, or mere change of shape. To exhibit the distortion without expansion, one-third of the expansion (vectorised) must be deducted. Thus

$$\mathbf{N}\nabla.\mathbf{G}=(\mathbf{p}_\mathbf{N}-\tfrac{1}{3}\mathbf{N}\operatorname{div}\mathbf{G})+\tfrac{1}{3}\mathbf{N}\operatorname{div}\mathbf{G}-\tfrac{1}{2}\mathrm{V}\mathbf{N}\operatorname{curl}\mathbf{G} \quad (309)$$

shows the separation of the strain into a distortion (without change of size), an expansion, and a rotation, which are naturally independent.

If distortion, expansion, and rotation are all elastically resisted, three independent elastic constants (in an isotropic medium) intervene between the above strain and the corresponding stress $\mathbf{P}_\mathbf{N}$ upon the plane whose normal is $\mathbf{N}$. To obtain $\mathbf{P}_\mathbf{N}$, multiply the distortional part by $2n$, the expansional part by $3k$, and the rotational part by 2ν, and add the results. Thus,

$$\mathbf{P}_\mathbf{N}=2n(\mathbf{p}_\mathbf{N}-\tfrac{1}{3}\mathbf{N}\operatorname{div}\mathbf{G})+\mathbf{N}k\operatorname{div}\mathbf{G}-\nu\mathrm{V}\mathbf{N}\operatorname{curl}\mathbf{G}. \quad (310)$$

Compare with (290). Here n and k are as before, whilst ν is a new elastic constant connected with the rotation, and which was previously assumed to have the value zero. That is, there was assumed to be no resistance to rotation. The corresponding torque is

$$\mathbf{S}=2\nu\operatorname{curl}\mathbf{G}. \quad . \quad . \quad . \quad . \quad . \quad (311)$$

With the rotational part of the stress is also associated translational force, given by

$$-\operatorname{curl}\tfrac{1}{2}\mathbf{S}=-\nu\operatorname{curl}^2\mathbf{G}. \quad . \quad . \quad . \quad (312)$$

Adding this on to the former expression for the force (or deriving the force from (310) directly), we find that

$$\mathbf{F}=n(\nabla^2\mathbf{G}+\tfrac{1}{3}\nabla\operatorname{div}\mathbf{G})+k\nabla\operatorname{div}\mathbf{G}-\nu\operatorname{curl}^2\mathbf{G} \quad (313)$$

represents the translational force to be used in the equation of motion (307). We should notice here that the quantity $k\operatorname{div}\mathbf{G}$ in (310) represents a uniform tension. It equals one-third of the sum of the normal tractions on any three mutually perpendicular planes. Its negative represents the pressure, or $p=-k\operatorname{div}\mathbf{G}$. Now when there is incompressibility, k is infinite, and $\operatorname{div}\mathbf{G}$ is zero. But their product usually remains finite. So in any case we may replace the k term in (310) by $-\mathbf{N}p$, and the k term in (313) by $-\nabla p$.

The energy of the strain is

$$\mathrm{U}=\tfrac{1}{2}(\mathbf{P}_1\nabla_1+\mathbf{P}_2\nabla_2+\mathbf{P}_3\nabla_3)\mathbf{G}, \quad . \quad . \quad . \quad (314)$$

or one-half the sum of the scalar products of the stress vector and the strain vector for three perpendicular planes, $\mathbf{P}_1$, $\mathbf{P}_2$, $\mathbf{P}_3$ being the stresses on the $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ planes respectively. On reckoning up, by (310), (309), we find the energies of expansion, rotation, and distortion are all independent, and that U is their sum, given by

$$\mathrm{U}=n[\mathbf{p}_1^2+\mathbf{p}_2^2+\mathbf{p}_3^2-\tfrac{1}{3}(\operatorname{div}\mathbf{G})^2]+\tfrac{1}{2}k(\operatorname{div}\mathbf{G})^2+\tfrac{1}{2}\nu(\operatorname{curl}\mathbf{G})^2, \quad (315)$$

where the ν term is the energy of rotation ($=\frac{1}{2}$ torque $\times$ rotation), the k term is the energy of expansion, and the n term the energy of distortion.

Now the stress (310) is derived from the strain (309) by the introduction of elastic resistances only. There is, however, no reason why we should limit the nature of the resistance in this way. Consider the n term only for example, relating to distortion. There may also be dissipative or frictional resistance to distortion. To exhibit it, change n to $n_0+n_1(d/dt)$ in (310), (313). Then n_0 will be the rigidity and n_1 the viscosity, or coefficient of frictional resistance to distortion. For instance, if we abolish n_0 and ν, and retain ν_1 and k, we have the stress in a real viscous fluid according to Stokes's theory. It may be that there is not a complete disappearance of the rigidity in a fluid; if so, then retain both n_0 and n_1. When the rigidity is marked, as in a solid, n_0 is the important part of n; whilst in a fluid it is the other part. It is, however, not at all to be expected that the expression of the viscosity of solids by n_1, if true at all, would extend beyond the small range of approximately perfect elasticity. Lord Kelvin's experiments on the subsidence of the oscillations of wires tended to show that a different law was followed than that corresponding to the viscosity of fluids, and that elastic fatigue was concerned in the matter.

There may also be, conceivably, inertial resistance to distortion, and not only elastic, but also frictional and inertial resistance to rotation, and the same with respect to expansion. These will be brought in by generalising the three elastic constants k, n, and ν of (310) thus:—

$$\left.\begin{aligned}k&=k_0+k_1(d/dt)+k_2(d^2/dt^2),\\n&=n_0+n_1(d/dt)+n_2(d^2/dt^2),\\\nu&=\nu_0+\nu_1(d/dt)+\nu_2(d^2/dt^2),\end{aligned}\right\} \quad . \quad . \quad (316)$$

where of the nine coefficients on the right side, the first three are elastic constants, the second three dissipative constants, the last three inertial constants; the elastic constants involving potential energy, the dissipative constants waste of energy, and the inertial constants kinetic energy, similarly to (307) as regards translation. Out of these twelve constants only four are in use, or seven, if ν_0 and ν_1, and ρ_1 be included, which additionals have been speculatively employed. This does not represent finality by any means; but sufficient has been said on the subject of generalising the elastic constants to emphasize

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the fact that there is plenty of scope for investigation in the theory of the motion of media of unknown internal constitution, which, externally viewed, involve the four elements translation, rotation, expansion and distortion.

The activity of the stress vector $\mathbf{P}_N$ is $\mathbf{P}_N\mathbf{q}$, and the flux of energy is (*see* §§ 68, 72 also), if q be the speed, or tensor of the velocity.

$$\mathbf{q}(U+T)-\mathbf{Q}_q q, \quad . \quad . \quad . \quad . \quad . \quad (317)$$

where U and T are the complete potential and kinetic energies, per unit volume, and $\mathbf{Q}_N$ is the stress conjugate to $\mathbf{P}_N$, to obtain which change the sign of the last (rotational) term in (310). The convergence of the energy flux represents the work done and stored or wasted in the unit volume. Considering the term $\mathbf{Q}_q q$ only (the rest being the convective flux of energy), its convergence is

$$\begin{aligned}\operatorname{div}(\mathbf{Q}_1 q_1+\mathbf{Q}_2 q_2+\mathbf{Q}_3 q_3)&=\nabla_1(\mathbf{P}_1\mathbf{q})+\nabla_2(\mathbf{P}_2\mathbf{q})+\nabla_3(\mathbf{P}_3\mathbf{q})\\&=q_1\operatorname{div}\mathbf{Q}_1+q_2\operatorname{div}\mathbf{Q}_2+q_3\operatorname{div}\mathbf{Q}_3+\mathbf{Q}_1\nabla q_1+\mathbf{Q}_2\nabla q_2+\mathbf{Q}_3\nabla q_3\\&=\mathbf{F}\mathbf{q}+(\mathbf{P}_1\nabla_1+\mathbf{P}_2\nabla_2+\mathbf{P}_3\nabla_3)\mathbf{q}, \quad . \quad . \quad . \quad (318)\end{aligned}$$

where $\mathbf{F}$ is the force as in (313). $\mathbf{F}\mathbf{q}$ is the translational activity, which may, by (307), be employed in increasing kinetic and potential energy or be wasted. The rest represents the rate of increase of the sum of the three potential energies when there is merely elastic resistance; but if we use (316) we obtain also the sum of the rates of waste of energy, through k_1, n_1, ν_1, and also the rate of increase of the sum of the kinetic energies, through k_2, n_2, ν_2.

Thus we have, by (310),

$$\begin{aligned}&(\mathbf{P}_1\nabla_1+\mathbf{P}_2\nabla_2+\mathbf{P}_3\nabla_3)\mathbf{q}\\&=\frac{d\mathbf{q}}{dx}\Big(2n(\mathbf{p}_1-\tfrac{1}{3}\mathbf{i}\operatorname{div}\mathbf{G})+k\mathbf{i}\operatorname{div}\mathbf{G}-\nu\mathbf{V}\mathbf{i}\operatorname{curl}\mathbf{G}\Big)\\&+\frac{d\mathbf{q}}{dy}\Big(2n(\mathbf{p}_2-\tfrac{1}{3}\mathbf{j}\operatorname{div}\mathbf{G})+k\mathbf{j}\operatorname{div}\mathbf{G}-\nu\mathbf{V}\mathbf{j}\operatorname{curl}\mathbf{G}\Big)\\&+\frac{d\mathbf{q}}{dz}\Big(2n(\mathbf{p}_3-\tfrac{1}{3}\mathbf{k}\operatorname{div}\mathbf{G})+k\mathbf{k}\operatorname{div}\mathbf{G}-\nu\mathbf{V}\mathbf{k}\operatorname{curl}\mathbf{G}\Big)\\&=2n(\mathbf{p}_1\nabla_1\mathbf{q}+\mathbf{p}_2\nabla_2\mathbf{q}+\mathbf{p}_3\nabla_3\mathbf{q})-\frac{2n}{3}\operatorname{div}\mathbf{D}\operatorname{div}\mathbf{q}\\&\qquad+k\operatorname{div}\mathbf{D}\operatorname{div}\mathbf{q}+\nu\operatorname{curl}\mathbf{D}\operatorname{curl}\mathbf{q} \quad . \quad . \quad . \quad (319)\end{aligned}$$

Take for illustration, the rotational term $\nu\operatorname{curl}\mathbf{D}\operatorname{curl}\mathbf{q}$. This is simply $(d/dt)\{\frac{1}{2}\nu(\operatorname{curl}\mathbf{G})^2\}$, or the rate of increase of the rotational energy, when ν is a constant, but when we use the last of (316) it becomes

$$\frac{d}{dt}\Big(\tfrac{1}{2}\nu_0(\operatorname{curl}\mathbf{G})^2\Big)+\tfrac{1}{2}\nu_1(\operatorname{curl}\mathbf{q})^2+\frac{d}{dt}\Big(\tfrac{1}{2}\nu_2(\operatorname{curl}\mathbf{q})^2\Big), \quad (320)$$

showing the rates of increase of potential and kinetic energy, and the rate of waste (the middle term) due to rotational friction. Similarly as regards the other terms in (319). The expansion terms give

$$\frac{d}{dt}\Big(\tfrac{1}{2}k_0(\operatorname{div}\mathbf{G})^2\Big)+\tfrac{1}{2}k_1(\operatorname{div}\mathbf{q})^2+\frac{d}{dt}\Big(\tfrac{1}{2}k_2(\operatorname{div}\mathbf{q})^2\Big), \quad . \quad (321)$$

where the middle term is the rate of waste, and the others rates of increase of potential and kinetic energies. Finally, the distortional terms of (319) give

$$\begin{aligned}&\frac{d}{dt}n_0\Big(\mathbf{p}_1^2+\mathbf{p}_2^2+\mathbf{p}_3^2-\tfrac{1}{3}(\operatorname{div}\mathbf{G})^2\Big)\\&+2n_1\Big(\dot{\mathbf{p}}_1^2+\dot{\mathbf{p}}_2^2+\dot{\mathbf{p}}_3^2-\tfrac{1}{3}(\operatorname{div}\mathbf{q})^2\Big)\\&+\frac{d}{dt}n_2\Big(\dot{\mathbf{p}}_1^2+\dot{\mathbf{p}}_2^2+\dot{\mathbf{p}}_3^2-\tfrac{1}{3}(\operatorname{div}\mathbf{q})^2\Big), \quad . \quad . \quad (322)\end{aligned}$$

where the first line is the rate of increase of the potential energy, the second line the frictional rate of waste, and the third line the rate of increase of kinetic energy. We thus complete the energy relations of the stress with the generalised elastic constants, and so far as small motions are concerned, the equations are manageable.

§ 146. Comparisons between the propagation of electromagnetic disturbances in Maxwell's ether, or in a homogeneous isotropic dielectric, whether conducting or not, and the propagation of motion in an elastic solid, either simple or generalised, may be made in a variety of ways. They all break down sooner or later, but are nevertheless useful as far as they go. A few cases will be now considered, based on the preceding. First take the case of a non-conducting dielectric at rest, and compare it with the regular elastic solid made incompressible by infinite resistance to compression. The incompressibility includes inexpansibility.

In the dielectric we have, if p stands for d/dt, for convenience,

$$\operatorname{curl}(\mathbf{H}-\mathbf{h})=cp\mathbf{E},\ \operatorname{curl}(\mathbf{e}-\mathbf{E})=\mu p\mathbf{H}, \quad . \quad (323)$$

the circuital equations connecting $\mathbf{E}$ and $\mathbf{H}$ (§§ 38, 24, 66), where $\mathbf{e}$ and $\mathbf{h}$ are impressed, and μ, c are the inductivity and permittivity. Now, the equation of motion in an incompressible solid is, by (273),

$$\mathbf{f}_1=(\rho p^2-n\nabla^2)\mathbf{G}=\Big(\rho p-\frac{n}{p}\nabla^2\Big)\mathbf{q}, \quad . \quad . \quad (324)$$

where ρ and n are the density and rigidity, $\mathbf{G}$ the displacement, $\mathbf{q}$ the velocity, and $\mathbf{f}_1$ the circuital part of the impressed forcive, the divergent part being inoperative. Or we may take the impressed forcive to be circuital to begin with.

Now, let $\mathbf{h}=0$, and $\mathbf{e}$ be finite. If it has no curl, it does nothing, as before shown (§ 89). The source of disturbance is $\operatorname{curl}\mathbf{e}$. This being the case in the dielectric, and $\mathbf{f}_1$ being the source of motion in the solid, it will be convenient to take $\mathbf{f}_1$ and $\operatorname{curl}\mathbf{e}$ as corresponding. Let the latter be (temporarily) $\mathbf{f}$. Then (323) gives (remembering that $\operatorname{div}\mathbf{H}=0$),

$$\mathbf{f}=\mu p\mathbf{H}+\operatorname{curl}\mathbf{E}=\mu p\mathbf{H}+\operatorname{curl}^2\mathbf{H}/cp,$$

or,

$$\mathbf{f}=\Big(\mu p-\frac{\nabla^2}{cp}\Big)\mathbf{H}=\Big(\mu p^2-\frac{\nabla^2}{c}\Big)\frac{\mathbf{H}}{p}. \quad . \quad . \quad (325)$$

Comparing this with the second of (324), and assuming the equality of $\mathbf{f}$ and $\mathbf{f}_1$, we see that $\mathbf{H}$ is velocity, μ density, c^{-1} rigidity; and so on. $\mathbf{H}/p$ means the time-integral of $\mathbf{H}$. Or, more explicitly, let $\mathbf{Z}$ be the time-integral of $\mathbf{H}$, so that $\mathbf{H}=p\mathbf{Z}$; then

$$\mathbf{f}=(\mu p^2-c^{-1}\nabla^2)\mathbf{Z}, \quad . \quad . \quad . \quad . \quad (326)$$

which compares with the first of (324). Thus

	$\mathbf{Z}=\mathbf{H}/p$	corresponds to	$\mathbf{G}$,	(spacial displ),
(mag. force)	$\mathbf{H}=p\mathbf{Z}$	,,	$\mathbf{q}$,	(velocity),
(el.current)	$\operatorname{curl}\mathbf{H}$	,,	$\operatorname{curl}\mathbf{q}$,	(2 × spin),
(el. displ.)	$\mathbf{D}=c\mathbf{E}$	,,	$\operatorname{curl}\mathbf{G}$,	(2 × rotation),
(inductivity)	μ	,,	ρ,	(density),
(permittivity)	c	,,	$1/n$,	(compliancy),
(mag. source)	$\mathbf{f}=\operatorname{curl}\mathbf{e}$	,,	$\mathbf{ff}$,	(impd. force),
(mag. energy)	$\frac{1}{2}\mu\mathbf{H}^2$	,,	$\frac{1}{2}\rho\mathbf{q}^2$,	(kin. energy).

This is, as far as it goes, an excellent analogy, particularly on account of its directness and ease of application, and on account of the similarity of sources. The disturbances of $\mathbf{H}$ generated by $\mathbf{f}$ in the dielectric and propagated away at speed $(\mu c)^{-\frac{1}{2}}$ are precisely represented by the velocity generated by similarly distributed impressed Newtonian force, which is propagated in the same manner through the solid at the equivalent speed $(n/\rho)^{\frac{1}{2}}$. Of course the correspondence at similar moments also applies to the other quantities compared.

But it is imperative (in general) that the motions in the solid should be small. The disturbances should therefore be of the fluctuating or alternating character, so that $\mathbf{Z}$, the time-integral of $\mathbf{H}$, does not mount up. For, correspondingly, if this were allowed, then $\mathbf{G}$ would mount up, and the elastic solid get too much out of shape to allow us to treat d/dt at a fixed point and $\delta/\delta t$ for a moving particle as identical.

Observe also, that the electric energy $\frac{1}{2}c\mathbf{E}^2$ is not matched by the potential energy of distortion; although their total amounts are equal, their distributions are entirely different. This is a fatal failure in detail. Nor have we any right to expect that a scheme like Maxwell's, depending upon rotations, can be perfectly matched by one which depends on shears.

§ 147. Another analogy of the same class is got by making the displacement in the solid represent the time-integral of $\mathbf{E}$ in the dielectric. Thus let $\mathbf{e}=0$ in (323), and $-\operatorname{curl}\mathbf{h}=+\mathbf{g}$. It is now $\mathbf{g}$ that is the source. Eliminate $\mathbf{H}$ between the two equations (323). We get

$$cp\mathbf{E}+\mathbf{g}=\operatorname{curl}(-\operatorname{curl}\mathbf{E})/\mu p. \quad . \quad . \quad . \quad (327)$$

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Or, since div $\mathbf{E}=0$ (when there is no electrification)

$$\mathbf{g}=\left(cp-\frac{\nabla^2}{\mu p}\right)\mathbf{E}=\left(cp^2-\frac{\nabla^2}{\mu}\right)\mathbf{A}, \quad . \quad . \quad (328)$$

if $\mathbf{A}=\mathbf{E}/p$, making $\mathbf{E}=p\mathbf{A}$.

Comparing (327) with (324) for the solid, we see that we have $\mathbf{E}$ representing velocity, μ compliancy, c density, and so on, being a general turning over of all the quantities. Thus

$\mathbf{A}=\mathbf{E}/p$	corresponds to	$\mathbf{G}$ (displacement),
μ	,,	n^{-1},
c	,,	ρ,
(el. force) $\mathbf{E}$	,,	$\mathbf{q}$ (velocity),
$\frac{1}{2}c\mathbf{E}^2$	,,	$\frac{1}{2}\rho\mathbf{q}^2$,
$\mathbf{H}$	,,	n curl $\mathbf{G}$,
$-$ curl $\mathbf{h}$	,,	$\mathbf{f}_1$ (circuital impd. force).

The conclusions are similar as regards the generation and propagation of disturbances of the two kinds compared. There is a similar failure to before as regards the energy of distortion. It ought to be the magnetic energy $\frac{1}{2}\mu\mathbf{H}^2$ now, but it is not. This want of correspondence as regards one of the energies will be removed (and can only be removed) by doing away with the rigidity and substituting something else, which must, however, be equivalent in its results as regards the propagation of disturbances from place to place.

[**Corrections.**—In equations (302) and (303), last section, change $-$ to $+$. In second line after equation (305), for (301) read (303).]

(*To be continued.*)

A MODE OF VARYING THE CANDLE-POWER OF ARC LAMPS, ARRANGED TWO IN SERIES ON 110-VOLT CIRCUITS.*

BY P. VITTE.

In many instances it is a useful thing to be able at will to regulate the current taken by arc lamps by merely adjusting a rheostat without touching the mechanism of the lamp itself, and without disturbing the working. I will take the case of two lamps in series on a 110-volt circuit, a problem easily solved, though the conditions to be fulfilled exclude all lamps with series-wound electro-magnets. The lamps employed should have only a single shunt-wound electro-magnet, serving both for striking the arc and for regulation. Such lamps are the Brianne and that of the Société Alsacienne. I used the latter make, and they gave every satisfaction, both from the point of view of striking the arc and of regulation.

I lay stress on the two following statements, well known to all practical men:—(i.) The difference of potential between the two carbons increases in proportion to the length of the arc, and is independent of the value of the current. (ii.) The normal arc practically corresponds to 40 volts within wide limits.

In order to state the case precisely let us take for example an inferior homogeneous 9mm. and a good cored 14mm. carbon, and assume that the current feeding the lamp is 5 amperes. If we suddenly increase the current to 12 amperes by altering the regulating resistance we shall see that the pressure at the lamp terminals does not vary. Strictly speaking, it varies momentarily while the length of the arc is altering, and then immediately returns to its original value, only to increase again as the carbons are consumed. This confirms my first statement. On the other hand, if the lamp mechanism has been set for 40 volts, and if we give the current successive values of 5, 6, 7, 8, 9, 10, 11, and 12 amperes, we shall find that in all cases the arc remains sensibly normal—neither too large nor too small. It is, however, as well to employ carbons suited to the average current for which the lamp is intended. The following are the sizes generally employed:—

6	amperes	9	to 14	mm.	carbons.
9	,,	10	,, 16	,,	,,
12	,,	11	,, 18	,,	,,

In all these different cases we always find that the pressure of 40 volts gives regular results.

When the two lamps have each been adjusted to 40 volts, we shall lose 30 volts in the resistance at 110 volts. It will consequently be sufficient to fit up a hand rheostat, enabling the consumer to run according to his requirements at from 5 to 12 amperes. The efficiency evidently remains the same under all conditions, since the energy lost in the rheostat is always $\frac{30}{110}$ of the total energy supplied. By making these sudden changes from 5 to 12 and from 12 to 5 amperes we obtain lighting effects practically without affecting the regular working of the lamp.

The practical adjustment of two arc lamps of this kind is extremely simple. With 110 volts between the points A and B (*see* Figure), we place the rheostat R, the lamps L and L', the switch C, and an ordinary fuse, all in series. Having closed the switch and struck the arcs, and the rheostat having been adjusted approximately to the current with which we wish to work ($Ri=30$ volts), the first thing to do is to see if the poles are right. The crater, as is well known, ought to be formed at the end of the upper carbon, which has to give out most of the light, and it has, therefore, to be connected to the + terminal. The craters being at the bottom of the upper carbons, we may now proceed to the adjustment. To effect this we begin by lengthening or shortening one of the arcs by manipulating the regulating mechanism, either preventing it from acting or making it act, without troubling ourselves about the current or the other lamp, until the arc under treatment has its normal value, which one can see by the pressure at the terminals, being 40 volts, or by signs which I will detail further on. The first lamp regulating at the required pressure, we can now pass on to the second lamp, upon which we operate in a similar manner. The two lamps being adjusted we go to the rheostat, which enables us to bring the current to the required value.

When an arc is too long the lower carbon flattens, and the arc flares and flickers. When the arc is too short, the lower carbon is surmounted by a tip, and forms a screen in front of the crater, which diminishes the luminous efficiency. With a normal arc the lower carbon is terminated by a rounded knob. Looking perpendicularly at the axis of the carbons, we ought to see a gap of about one millimetre between the two carbons; sometimes a little less, sometimes more (for instance, in 25 ampere arcs). As soon as we exceed 12 amperes we are obliged to adopt somewhat higher terminal pressures than 40 volts. An examination of the arc in the light of the above remarks should be a guide to the electrician.

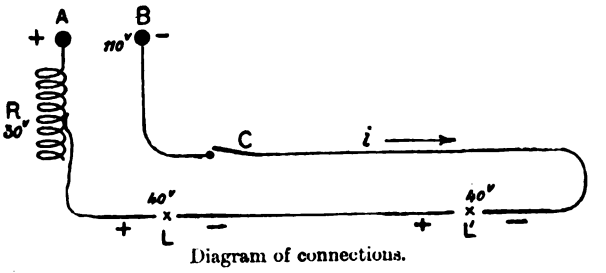

Diagram of connections.

From the point of view of efficiency it is evidently advantageous to have arcs as long as possible. In reality, 40 volts is the average pressure; according to circumstances, we regulate arcs at from 38 to 42 volts. For instance, the mechanician should adjust for 41 volts, the pressure falling at the moment of feeding to 40 volts.

We have

$$110\,\mathrm{V}=\mathrm{R}\,i+\varepsilon+\varepsilon'$$
$$0=\mathrm{R}\,di+d\varepsilon+d\varepsilon'=\mathrm{R}\,di+2\,d\varepsilon$$

since the two lamps are under the same conditions as to consumption. Hence $di=-\frac{2d\varepsilon}{\mathrm{R}}$. The variation of current is less for a given variation of the terminal pressure the greater R is.

If the lamp feeds for a variation of one volt, the maximum variation of current for 10-ampere lamps, with $\mathrm{R}=3$ ohms, will be $\Delta i=\frac{2}{3}$ ampere. In reality, the two lamps rarely feed simultaneously, and it is therefore easy to see that the variations of current are less. The maximum variation of current for the same lamps working at 5 amperes will be $\frac{2}{6}=\frac{1}{3}$ ampere, since $\mathrm{R}=6$ ohms in this instance. We see, therefore, that the relative variation of the current due to feeding remains the same for all values of the current which traverses two given lamps. Two 10-ampere lamps of the type selected for this investigation, running off a 110-volt circuit and absorbing 30 volts in the resistance, keep the current steady to within half an ampere.

To regulate differential lamps arranged two in series on a 110-volt circuit, the following practical rules may be relied on. (1) Owing to the solidarity of the arcs if we lengthen one we shorten the other. The thing to be done is, therefore, to bring the arcs to equality while bearing this fact in mind. (2) If we lengthen the two arcs together the pressure at the lamp terminals increases, and the current diminishes, and inversely if we shorten the two arcs together the pressure at the lamp terminals decreases and the current increases. (3) If we diminish the regulating resistance the pressure at the lamp terminals and the current both increase, and inversely, if we increase the resistances, the pressure at the lamp terminals falls and the current decreases.

By bearing these facts in mind we are able to quickly adjust two differential arc lamps from the point of view of length of arc and of current without too many tentative attempts.

* From *L'Électricien, Revue Internationale de l'Électricité.*

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MICROSCOPE READINGS OF GALVANOMETERS.

Few if any attempts are made in this country to read galvanometer deflections in any other way than by the movement of a needle on a dial, or by the motion of a spot of light on a scale. The former is only suitable for rough instruments, though capable of yielding good results in the hands of trained men, as in the case of the tangent galvanometers of the Post Office; but difficulties of parallax and the need for double readings limit the use of pointers, as a rule, to an accuracy of half a degree. One-tenth of a millimetre may be estimated by a practised observer with a first-rate mirror galvanometer; but between these two there is a wide range of readings which may be filled in by microscope readings. Telescope readings are common on the Continent, but the observer generally sits at a considerable distance from the instrument. There is no reason for this; a microscope and a telescope are essentially identical instruments, and differ only in the focal length of the lenses. Microscopes are largely employed in astronomical work and on surveying instruments, but a more simple arrangement is sufficient for a galvanometer. A flat mirror should be used, and the reflected image of a concentric cylindrical scale should be observed by a short focus telescope or long focus microscope. Instrument makers should turn their attention to the construction of such instruments with large lenses, and giving a wide field.

One of the advantages of galvanometers of the d'Arsonval type lies in the fact that the coil is attached at top and bottom by a wire. This makes the instrument more substantial, and at the same time renders the coil less liable to side motions than is the case with the needle of an ordinary THOMSON galvanometer. The motion of the spot of light on a scale is entirely due to the angular motion of the needle,

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as side motions are not magnified by the mirror method. Unfortunately, this is not the case if a microscope is used to measure the movement of the extremity of a short pointer attached to the needle. The microscope method would be far more sensitive than the mirror method, and would long ago have superseded it in laboratories were it not for the fact that lateral motions of the needle (due to pendulum action) produce as great, if not greater, effect than the angular motions to be measured. But if these side motions can be got rid of by the use of very light coils suspended at both ends, or in any other way, the microscope method is in many ways preferable to the mirror or telescope methods, the use of either of which practically so enlarges the instrument that it occupies a considerable space. The Cardew voltmeter, or the sag form of hot wire voltmeter, seem to be instruments specially adapted to the microscope, and other examples could no doubt be found. The disadvantage of using any mechanical method of magnifying the indications of an instrument consists in the delicacy of the adjustment, or in the backlash of the parts. These defects are not found in optical methods. For practical instruments, telescopes are out of the question; but a cheap form of microscope does not appear so, and it is remarkable that so little attention has been devoted to its use.

Rather too much prominence has been given of late to standard galvanometers, which are carefully fixed in place and never moved, or to very sensitive or special forms. These are not likely to meet with the approval of engineers, who might be ready to use a substantial instrument which would stand as much knocking about and give as accurate readings as a four-inch theodolite. A galvanometer cannot be fairly compared with a theodolite, since not only the pendulum action but the "liveness" of the moving part are altogether different from the stiff-clamped vernier of the surveying instrument. But in instruments which are free from the pendulum difficulty, a vernier might easily be applied, by providing a short transparent scale in the eyepiece. A four-inch theodolite reads to one minute of arc, which is equivalent to 0·58 of a "Central Institution scale division." In recommending the attention of instrument makers to microscope methods of reading, we would only add that the theodolite was developed by engineers, and has arrived at its present form by the modifications suggested by engineers, and it is essentially an engineer's instrument.

REVIEWS.

Dynamo-electric Machinery. By SILVANUS P. THOMPSON. Fourth edition, enlarged and revised. (London: E. and F. N. Spon. 1892.)

The fourth edition of a standard work does not generally require a long review; but the volume before us is of so great value, by reason of the importance of its contents and the rapid development of the subjects with which it deals, that it deserves nearly as much attention as a new book. Since the appearance of the first edition in 1884 no other writer has attempted to compete with it; and the unique position which it holds as the only comprehensive treatise on dynamo-electric machinery increases the responsibility of the author in providing electrical engineers with a complete and trustworthy text-book. In the attempt to discharge this responsibility the whole work has been revised, very little omitted, and much, including new chapters on alternating motors, the theory of armature winding, dynamo design, transmission of power, and the management of dynamos, has been added, together with a number of folding plates giving scale drawings of various machines. The volume, as a result, is of an unwieldy size, and of such a thickness that nothing but the very strongest binding will hold it together. Including as it does the history, theory, practical design, and description of examples, two if not three volumes might have been made, two being works of reference, and one for workshop or office use.

The historical chapter is so short that it need only be mentioned to commend it for its brevity. In the earlier editions a great deal of space was occupied with descriptions and illustrations of experimental, unsuccessful, and obsolete machines. Copious references to fuller accounts of these early forms are given in footnotes, and many of these refer to patent specifications. We notice that the account of Isenbeck's research on the action of the Gramme ring, together with the author's experiments on the effect of pole-pieces, have been omitted in the new edition. These experiments were of considerable interest, but the conclusions drawn from them were open to question. The diagrams of different modes of connecting field-magnet circuits, which have been copied into dozens of books, including even pocket-books, have been re-engraved with modernised outline, the change recalling the modification of the Edison dynamo by Hopkinson. The chapter on armature reaction brings together some very valuable information, but we find no warning of the troubles of large dynamos, especially of two-pole ring armatures. It is impossible to build these above a certain size. A note on this point might be added at the end of Chapter V., in which the theoretical relation of output to efficiency is discussed. The act of commutation of a section of an armature is clearly shown in a diagram, and some useful hints are given about sparking. It is evident, says the author, that sparklessness will be promoted by, amongst other methods, so shaping the pole surfaces as to give a suitable fringe of magnetic field of graduated intensity. More definite information on this point, if it could be given, would be useful to more than one firm of dynamo builders, who have had immense trouble with multipole machines, and who have only cured their sparking by paring away the pole-pieces. An excellent diagram is given showing the generation of eddy currents in core discs; but further information might be given as to the degree of lamination necessary in different cases. A general rule is given (p. 98) that they should not exceed 2 millimetres, and on p. 342, in a chapter on the practical construction of armatures, it is stated that the usual thickness is from 1 to 2mm. In the chapter on examples of modern dynamos, only one instance of the thicker limit is given, in the Mather and Platt dynamo described on pp. 412 and 520, where about 1,000 plates went to an armature of a gross length of 50·8cm. The Brown dynamos, described on p. 490, have discs of a thickness of 20 B.W.G. (rather less than 1mm.), and in the Phœnix dynamo, described on p. 417, the same thickness is used. In the other machines no data on this point are given. Some information on the effect of thickness of the discs on hysteresis and eddy-current losses might have been given with advantage in connection with the Kapp and Housmann method of testing such losses on p. 792. The Thomson law of economy might be applied in this case; but practically we believe that No. 20 gauge should not be exceeded, and some makers use thinner plates. A word of warning might have been introduced against the use of mild steel both for armature discs and for field magnets in general cases, in the admirable chapter on magnetic principles.

The following chapter (VII.), on the magnetic circuit, seems to be rather needlessly mathematical. If the book could be divided into theoretical and practical sections, or volumes, much of this would have to be classed in the former category, while the worked-out examples might be given in connection with rather more definitely expressed rules in the workshop volume. To the collection of forms of field magnets, which has been an interesting feature of former editions, several additional types are given; but the supposed advantages of the iron-clad fields are not discussed, nor is the real necessity for the use of more than two poles for large dynamos mentioned. The elementary theory of the dynamo is of little use to the manufacturer, and much of it really belongs to the Rankine order of engineering literature. The calculation of the fluctuations due to the number of commutator bars and setting of the brushes was worth investigating in the first instance, but is hardly of sufficient importance in general work to warrant its reappearance in the present edition. The theory of self-

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regulation is treated in a Rankine fashion, and the excellent practical rules for compounding are rather buried between mathematical formulæ and a diagram of characteristics of very old-fashioned compound-wound machines.

The new chapter (XII.) on the winding of armatures and the theory of connections is a most elaborate and remarkable study, and the first five diagrams of ring and drum winding are the perfection of clearness. The developed diagrams of winding which are given side by side with the circular diagrams are a most important addition, and not only render the examination of any peculiar mode of winding very much more easy, but should be of great value for drawing office and workshop use. Winding tables, or directions to the armature winder, are a little difficult to follow; but each engineer and indeed many winders have their own ideas on this subject, and the introduction of a new system, however perfect, might lead to serious trouble. Each maker, too, sticks as a rule to one mode of winding; and while the diversity of windings and the great complication of some of them speak highly of the immense pains which the author has taken in collecting and clearly illustrating them, the student, and the mechanical engineer who studies this book for the purpose of learning how to build dynamos, need not be staggered and disheartened at the intricacy of these pages. The next chapter, on the practical construction of armatures, is a welcome return to engineering. The most common way of mounting and driving the core, described as the Kapp mode of driving, is shown only in transverse section; a modification,—Brown's system is shown in perspective. Carbon brushes are said to be used now frequently, both for dynamos and motors, but it is singular that a special search at the Crystal Palace Exhibition revealed only one example. Bedplates are dismissed at the close of a chapter on mechanical points in design and construction, without reference to the important method introduced in connection with the Willans engine, at first to meet the stringent requirements of the Admiralty as to space and weight, but now commonly adopted in central-station work. A short account of the results of the committee of the Institution of Mechanical Engineers on friction and lubrication would be a valuable addition to this chapter.

The chapter (XVI.) on the elements of dynamo design is rather unequal. It contains a good deal of very valuable teaching, but much of it must be reduced to plain rules of a more or less empirical kind to make it fit for drawing-office work. Twice in this chapter it is remarked that modern practice allows from 2,000 to 3,000 amperes per square inch in armature conductors. The proper rules, based on the emissive surface, are given further on; and a useful table is given in an appendix, where this unscientific rule is again repeated in the immediate context of the correct one. It would be only fair to the student to tell him that dynamos are not designed in the manner described in this chapter in everyday work. After a few years' experience each manufacturer has an accumulation of records of tests and experiments on a series of machines of different sizes from which, with but little labour and trifling calculation, he can build any intermediate or modified machine with a much greater certainty of a specified output than can be relied upon by a steam-engine builder. Much of the calculation here given underlies the design of dynamos, just as thermodynamic considerations underlie steam-engine work. In striking out an altogether new departure these formulæ may be useful to those engineers who can thoroughly master them; but these are, and in all probability will be few, until engineering has made an enormous change.

The principles of alternate-current work are discussed very concisely, and the description of the best known types of dynamos confirms us in our opinion that these are in their infancy compared with continuous-current machines. A short chapter is devoted to transformers and their complicated mathematical theory which has attracted so undue a proportion of attention. The electric transmission of energy, regulators for dynamos, the testing and management of dynamos and motors bring this important and we may say indispensable book to a close. The arrangement of the contents is a great improvement upon that of former editions, and a descriptive heading is given to the alternate pages, as indeed should always be done.

DYNAMO BRUSHES.

An excellent opportunity is undoubtedly afforded by the Crystal Palace Exhibition for comparing the practice of various makers with regard to the details of dynamo design; indeed, it is extremely unlikely that so comprehensive a collection of machines will be shown again in this country for some time. We have taken the opportunity, therefore, of examining the kinds of brushes most in use at the Exhibition. For machines carrying heavy loads, wire gauze brushes seem to be preferred, brushes of this description also being adopted on machines exhibited by the Electric Construction Corporation, Messrs. Easton and Anderson, Johnson and Phillips, H. F. Joel and Co., Kent and Sharp, Cathcart, Peto, and Radford, Wilson Hartnell, Laurence, Scott and Co., the Roper Engineering Company, and the Newton Electrical Engineering Works. Copper wire brushes are in use on all Messrs. Siemens' machines, both alternating and continuous current, as well as on the Thomson-Houston alternator, a Thomson-Houston continuous-current dynamo having brushes of sheet copper terminating in a number of tongues or divided narrow strips. Ordinary sheet metal brushes are employed on most of the Laing, Wharton and Down machines, on those of Messrs. Crompton and Co., Messrs. Dorman and Smith, and Messrs. Appleton and Burbey.

In one case only could we discover an example of the adoption of carbon brushes. In a motor made by a French firm, Messrs. Piat and Co., for working an electric rivetter, we understand that four brushes are employed, two being of gauze and two of copper-plated carbon. We hear that carbon brushes are used in connection with the Davis and Stokes closed commutator for mining motors. American electric traction engineers say that carbon brushes are the greatest boon to them, and yet not a single one is visible at the Crystal Palace. Many experiments have been made with carbon brushes, and the theory of their action is fairly clear. They were first employed, we believe, on Prof. Forbes' uni-polar or non-polar dynamo, where they were used only as collectors, and their real advantage in smoothly short-circuiting commutator sections was not made use of at all. The difficulty appears to be, that they will not take anything like the current that is carried by a metallic brush.

THE USE OF WATER-POWER FOR ELECTRICAL PURPOSES.

BY NORMAN F. WILSON.

(*Continued from page 169.*)

Outward-Flow Turbines.

A very large number of this type of turbine are used on the Continent, on both high and low falls, for all kinds of work. That the efficiency of the wheel is in no way reduced when the diameter is increased is a great point in favour of the Girard, and others of the outward-flow type of turbine. This is especially important when the fall is very high and the speed of the periphery of the wheel is great in consequence, since by increasing the wheel in diameter the turbine shaft can be made to revolve at any given number of turns per minute. As an inward-flow turbine has always to be kept full of water if it is to work at its best efficiency, the size of the wheel is to a great extent dependent on the quantity of water which has to pass through it; a wheel cannot be indefinitely increased in diameter without causing a considerable loss in efficiency when the water is passing through it. Therefore, if the quantity be small, as is frequently the case when the fall is high, the wheel must be small in diameter, and the speed of the shaft becomes inconveniently high. The water acts on an outward-flow turbine by impact only, and need not be supplied to all the wheel at once it is quite sufficient if five or four, or even a single bucket at a time, be kept supplied. Moreover, when the water is passing through the vanes of the wheel it does not entirely fill them, so that the limitations in size which affect inward-flow turbines (and all others which are capable of working by suction) are entirely dispensed with, and the diameter of the

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wheel may be increased at pleasure. Outward-flow turbines are not so quite so efficient as inward-flow, are more liable to race, and are adversely affected by backwater when the level of the tailrace rises; but with a partial supply of water they give a much better efficiency than many turbines of other types.

Figs. 5 and 6 illustrate the general construction of a vertical outward-flow turbine for medium and high falls. The water entering through the mouth A, is directed by the guides C C on to the shaft F. The water does not entirely fill the buckets. The small holes G are for allowing the atmospheric pressure to reach the water freely; if these were not provided the water would tend to form a vacuum in the empty part of the vane which would retard its exit from the wheel.

Outward-flow turbines are most frequently placed horizontally with a vertical shaft, as by this arrangement very little fall is lost in allowing the water to leave the wheel freely; but

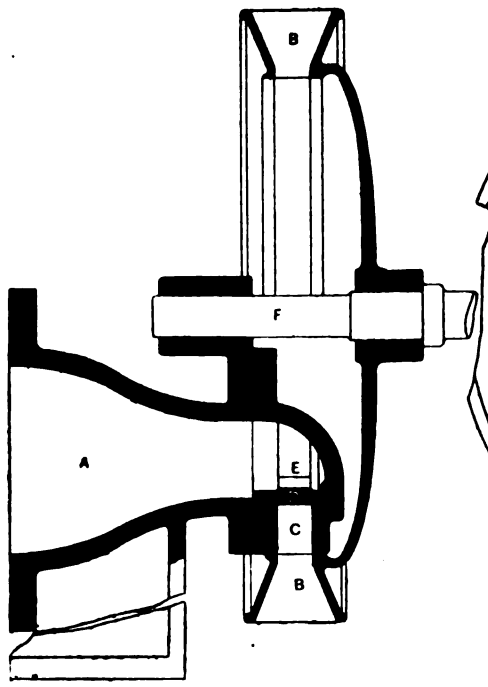

FIG. 5.—Vertical Outward-flow Turbine. Sectional Elevation.

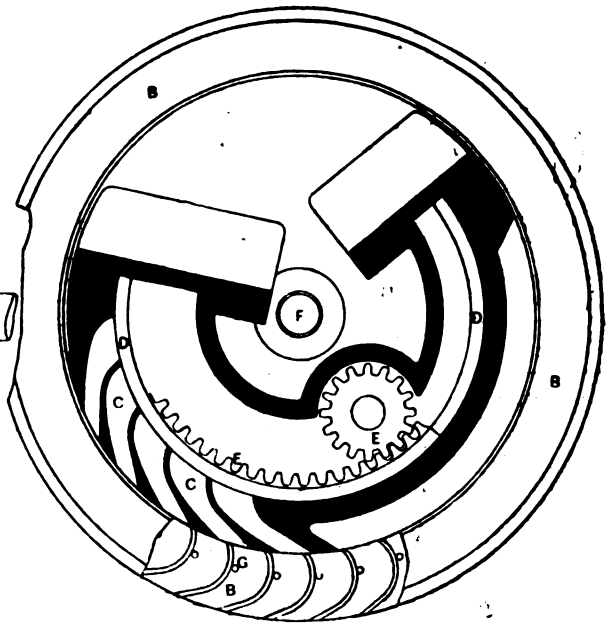

FIG. 6.—Vertical Outward-flow Turbine. Sectional Plan.

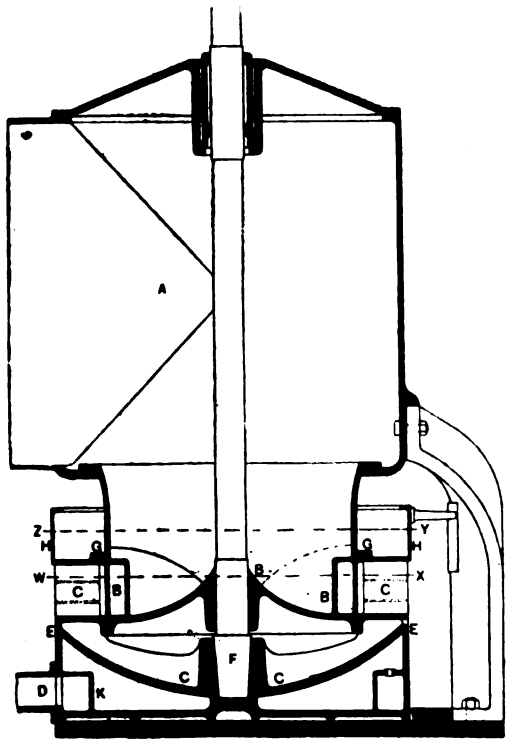

FIG. 7.—Fourneyron Outward-flow Turbine. Sectional Elevation.

when the fall is high and a foot or so can be sacrificed, they may be arranged with a horizontal shaft without detriment.

Figs. 7 and 8 show the elevation and plan of M. Fourneyron's outward-flow turbine. The water enters through the pipe A, and is directed by the guides B B against the vanes of the wheel C. The top of the guide blades are covered over at the

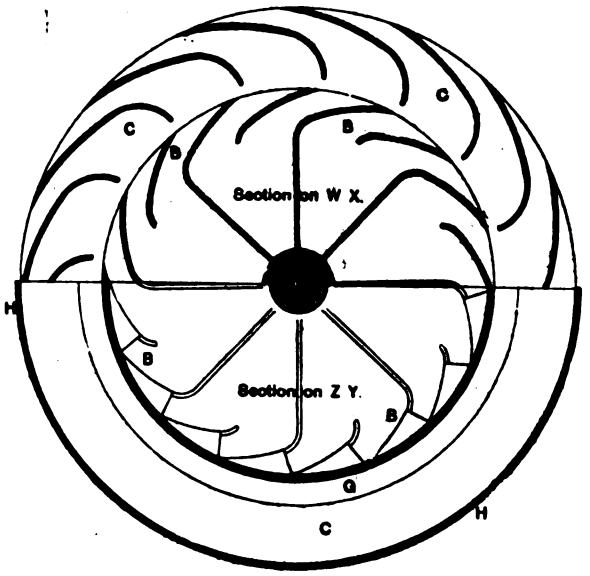

FIG. 8.—Fourneyron Outward-flow Turbine. Sectional Plan.

against the vanes of the wheel B. When the supply of water falls short, or it is desired to stop the motor, one or more of these passages, C C, can be closed by the brass slide D, which is moved backward or forward by the rack and pinion wheel E. In the figure all the guide passages are shown closed. The wheel B is generally made of brass or cast iron, and is keyed

point in order to control the direction of the water more efficiently. The metal strip G forms a water joint between the revolving wheel and the guide-blade chamber. H is a circular sluice for stopping the turbine. In order to avoid being obliged to support the weight of the wheel, shaft, and gearing on a wooden pivot, a small pipe, D, is taken from the supply pipe

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to the circular chamber K beneath the wheel. The whole of the under surface of the wheel C is thus subjected to the full pressure due to the head; this pressure, acting over so large a surface, is amply sufficient to carry the weight of the wheel, &c., and raises it a small fraction of an inch above the stationary casing E. The wheel then revolves on the thin film of water escaping between the casing E and itself. This arrangement (with modifications, *see* Fig. 10) can be adopted with very many turbines, which are placed at the bottom of the fall, and dispenses with the pivot or suspension bearing on the upright shaft. It is found to work well in practice, and the extra initial cost is not large.

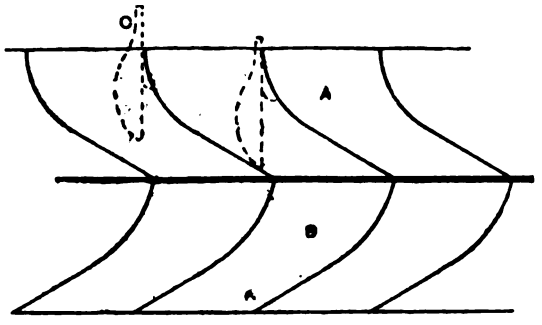

FIG. 9.—Axial-flow Turbine. Form of guide passages and vanes.

The turbine illustrated in Figs. 7 and 8 is not provided with any efficient apparatus for working with a partial supply of water. When it is desired to work a turbine of this class with only two-thirds, half, or a quarter of the full supply, the wheel is divided into two or more horizontal sections (as shown by the dotted lines in Fig. 7), and a circular regulating sluice is placed between the wheel and the guides; this sluice may be raised to admit the water into one or more divisions of the wheel, according to the power required. The disadvantage of

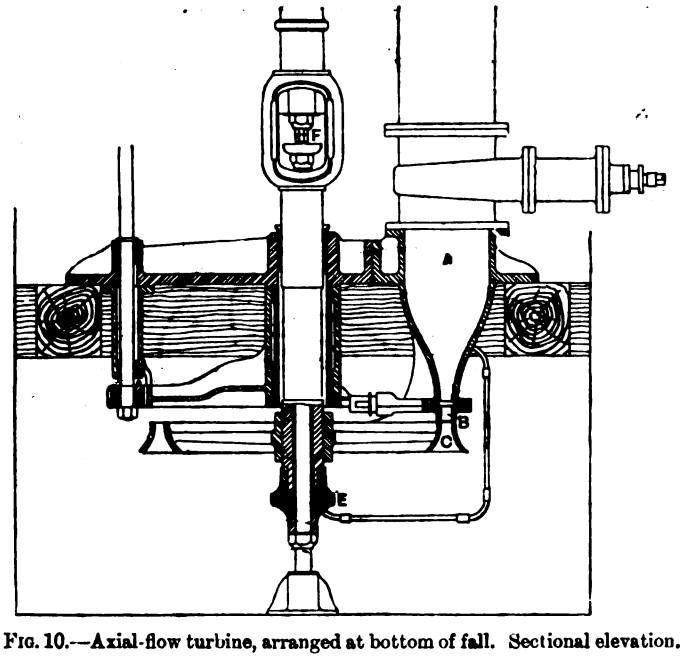

FIG. 10.—Axial-flow turbine, arranged at bottom of fall. Sectional elevation.

this method of regulation is that only two or three definite proportions of the power can be efficiently obtained; with intermediate powers it is not so satisfactory. A wheel divided in this manner becomes virtually two or three separate turbines.

Axial-Flow Turbines.

The axial-flow turbine is so called because the water approaches and leaves the wheel in a direction parallel with the shaft, which is generally vertical. M. Jonval, it is believed, was the first to bring this type of turbine into practical use; he was ably seconded in his efforts by M. Girard and other hydraulic engineers, and now these turbines are used and manufactured all over the world. This turbine gives a good efficiency, and runs more steadily under a varying load, than the outward-flow. It also possesses one advantage claimed for inward-flow turbines, in the fact that the wheel may be placed above the tail water level and part of the fall be utilised by suction. Fig. 9 shows the form of the guide passages and wheel vane of an axial-flow turbine; the stationary guide-blade chamber A being fixed above the revolving wheel B.

These turbines may either have the water admitted to them all round the wheel, or only to a few buckets at once, as in an outward-flow wheel. When the wheels have only partial admission the diameter of the wheel may be varied at pleasure without affecting the efficiency, and there is no difficulty in regulating the power; but in this case it cannot work by suction, and is hampered if the water rise in the tail race. When the water is supplied to all the buckets at once the diameter of the wheel cannot be increased so much, and the power cannot easily be varied, but the turbine may then be fixed so as to utilise part of the fall by suction, which is often a convenience. When the turbine is fixed in the latter position the best way to adapt the wheel for varying supplies is to divide it into concentric rings, the divisions running parallel to the shaft instead of being at right angles to it, as in Fig. 7. This method gives fairly good results, but adds considerably to the cost of construction. When these turbines are placed at the bottom of the fall (Fig. 10) there are many ways by which the guide passages may be reduced in area when the supply runs short. Some of these arrangements are not very practical, as their working is liable to be obstructed by sand and *debris*.

The method of partially closing the guide passages by vertical slides (Fig. 9), although in common use, is not to be recommended. In the first place, the slide often cannot be shut down without difficulty; and, secondly, the placing of a somewhat abrupt obstacle in the way of the water retards the velocity of its flow, and thereby reduces its working power. It is much better to entirely close a number of the passages either by flaps, which may be lowered over the posts, or by a slide, as is done in the turbine illustrated in Fig. 10, which shows how an axial-flow turbine is arranged at the bottom of the fall. The water comes down the pipe A on to the top of the guide blades B, and is directed by them on to the wheel C. The slide for opening and closing the guide passages is worked by the sector and pinion D. The wheel is keyed on to a hollow cast-iron shaft, whose weight is partly supported by the water-bearing E, and partly by the suspension-bearing F.

(To be concluded.)

THE MANAGEMENT OF BOILERS.*

Safety.

Overloading or neglect may lead to disastrous results. Safety valves should therefore be tried at least once every day to see that they act freely.

The pressure gauge should stand at zero when the pressure is off, and it should show the same pressure as the safety valve when that is blowing off. If not, one is wrong. Compare gauge with correct one.

Before starting see that the water is at the proper height. Do not rely on glass gauges, floats, or water alarms, but try the gauge cocks. If they do not agree with water gauge, learn the cause and correct it.

Gauge cocks and water gauges must be kept clean. Water gauges should be blown out frequently, and the glasses and passages to gauge kept clean. The Manchester Steam Users' Association attribute more accidents to inattention to water gauges than to all other causes put together.

The feed pump or injector should be kept in perfect order, and be of ample size. No make of pump can be expected to be continuously reliable without regular and careful attention. Have two means of feeding a boiler. Check valves and self-acting feed-valves should be frequently examined and cleaned. See that the valve is acting when the feed-pump is at work.

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In case of low water, immediately cover the fire with ashes (wet if possible) or any earth that may be at hand. If nothing else is handy use fresh coal. Draw fire as soon as it can be done without increasing the heat. Neither turn on the feed, start or stop engine, or lift safety valve until fires are out and the boiler cooled down.

Blisters and cracks are liable to occur in the best plate iron. When the first indication appears there must be no delay in having it carefully examined and properly attended to.

Fusible plugs, when used, must be examined when the boiler is cleaned, and carefully scraped clean on both the water and fire sides.

Economy.

Fire evenly and regularly, a little at a time. Moderately thick fires are most economical, but thin firing must be used when the draught is poor. Take care to keep grates evenly covered, and allow no air holes in the fire. Do not "clean" fires oftener than necessary. With bituminous coal, a "coking fire," *i.e.*, firing in front, and shoving back when coked, gives best results if properly managed.

All heating surfaces must be kept clean, outside and in, or there will be a serious waste of fuel. The frequency of cleaning will depend on the nature of fuel and water. As a rule, never allow over $\frac{1}{16}$in. scale or soot to collect on surfaces between cleanings. Hand-holes should be frequently removed and surfaces examined, particularly in case of a new boiler, until proper intervals have been established by experience. Examine mud-drum, if any, and remove the sediment therefrom. In using smoking fuel, it is best to occasionally brush the surfaces when steam is off.

Cold water should never be fed into any boiler when it can be avoided, but when necessary it should be caused to mix with the heated water before coming in contact with any portion of the boiler.

When foaming occurs in a boiler, checking the out-flow of steam will usually stop it. If caused by dirty water, blowing down and pumping up will generally cure it. In cases of violent foaming, check the draught and fires. If found to prime, lower the water-line.

Be sure that all openings for admission of air to boilers or flues, except through the fire, are carefully stopped. This is frequently an unsuspected cause of serious waste.

If feed-water is muddy or salt, blow off a portion frequently, according to condition of water. Empty the boiler every week or two, and fill up afresh. When surface scum-cocks are used, they should be often opened for a few minutes at a time. Make sure no water is escaping from the blow-off cock when it is supposed to be closed. Blow-off cocks and check-valves should be examined every time the boiler is cleaned.

Durability.

When leaks are discovered, they should be repaired as soon as possible. Never empty the boiler while the brickwork is hot.

Never pump cold water into a hot boiler. Many times leaks, and in shell boilers serious weaknesses and sometimes explosions, are the result of such an action.

Take care that no water comes in contact with the exterior of the boiler from any cause, as it tends to corrode and weaken the boiler. Beware of all dampness in seatings or coverings.

Examine frequently parts in contact with copper or brass, where water is present, for signs of corrosion. If water is salt or acid, some metallic zinc placed in the boiler will usually prevent corrosion, but it will need attention and renewal from time to time.

In boilers with thick plates or seams exposed to the fire, steam should be raised slowly, and rapid or intense firing avoided. With thin water tubes and adequate water circulation, no damage can come from that cause.

If a boiler is not required for some time, empty and dry it thoroughly. If this is impracticable, fill it quite full of water, and put in a quantity of common washing soda. External parts exposed to dampness should receive a coating of linseed oil.

All things about the boiler-room should be kept clean and in good order. Negligence tends to waste and decay.

Boiler Inspection.

The boiler should be examined externally for corrosion and leaks. All internal seams should be examined and effects of corrosion and pitting noted. Stays should be seen and tested by a hammer to ascertain if they are cracked or broken. After thorough examination test hydraulically with water at 180° to 210°F. to a pressure 50 per cent. greater than working pressure, the boiler having had time to become of uniform temperature throughout. While under pressure try flat surfaces with a straight-edge, and note any change of form, and test all external surfaces with light blows of a hammer. When pressure is off, permanent set or alteration of shape should be noted.

Fire-box stays or other stud stays may be drilled with an $\frac{1}{8}$in. hole deep enough to reach the water-space, and if leakage takes place renew the stay.

If set in brickwork, that which is in contact with the plates should be removed as far as possible. Man-hole and mud-hole covers, fire bars and bridge should be removed, and every part of boiler should be cleaned to facilitate inspection.

New boilers should be inspected every year, old ones every six months.

ELECTRIC SUPPLY AT OXFORD.

After the cramped and dark engine-rooms of most London stations, the generating station at Osney, on the outskirts of Oxford, is so light and airy as to remind one of a conservatory. The ample space in the engine-house, as well as the boiler-house, is, of course, partly due to the fact that only three sets of plant have as yet been laid down; there is room for another, making half the full complement, which will be added when required. Being free from the harassing restrictions of the Metropolitan Building Act, the side of the engine-room on which the future extension will be made is filled in with corrugated iron. The generating station is close to the Great Western Railway Station, and is situated on the bank of a branch of the upper river, from which condensing water, which is also well adapted for steaming, can be drawn. Three vertical triple-expansion engines by M'Laren, of Leeds, run at 120 revolutions per minute, and drive Elwell-Parker continuous-current dynamos by belts. The engines are surface-condensing, with the air pump at the back, and give 120 B.H.P. Fly-wheel governors are used to shift the eccentric of the high-pressure cylinder. Three multitubular locomotive boilers, also by M'Laren, supply steam through a ring main at 140lb, but it is intended at times of full load to use 160lb. if necessary. There is room for three more boilers of the same size. A Green's economiser is provided, and the result of the maker's steam trials was very satisfactory. Three smaller dynamos, driven by ropes from the shaft of the generating machines, are used as exciters, or for charging a small local accumulator of 53 11-L. E.P.S. cells. The generating dynamos are drum wound, with fine stranded conductors; the ends are not provided with strip end connections. The output of each is 80 amperes, at 1,050 volts, or 84 units, at 400 revolutions per minute. The switchboard at this station is remarkably simple. The left-hand part is provided with double-pole switches on omnibus bars, to which the generators are coupled in parallel. Two pairs of Silvertown cables, drawn into iron pipes, take the high-pressure supply into the town, where a central switch-station is provided in Broad-street. Ammeters, showing the current generated by each dynamo and by each exciter, are provided on the right hand, and a sliding resistance switch controls the shunts of the exciters. No regulation of pressure is attempted at present at the generating station, but a steady reading of 1,050 volts is maintained on a Thomson electrostatic voltmeter; but there seems to be no reason why a rather lower pressure could not be used during the day.

There are three sub-stations in Oxford, one at the switch station in Broad-street, one in King-street, and one in Queen-street, Carfax. At Broad-street a battery of 140 31-L accumulators of E.P.S. make are provided, together with a dynamotor or continuous-current transformer, similar to that shown at the

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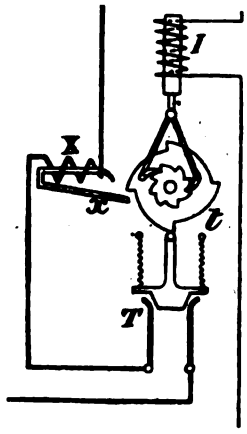
Crystal Palace Exhibition, and illustrated in *The Electrician*, Vol. XXVIII., p. 424. Dynamotors of the same size are placed in the other two stations, in which there is room for two more. The output of these machines is 360 amperes at 108 volts, and they are driven by a current of 40 amperes at 1,000 volts. They run at 500 revolutions per minute, and are continuously lubricated by circulating oil pumps.

The method of regulation and use of these dynamotors is fully described in the patents of Parker, Woodward and Rees, Nos. 16,110 (1890), 13,942 (1891), and 18,348 (1891). It is under the control of one man at the central switch station, where voltmeters are provided showing the pressure on the network from which the consumers take their supply at 105 volts. When, owing to the draught upon the mains, the pressure begins to fall, and it is necessary to feed the network by one of the dynamotors, the man in charge of the switch station closes a double pole switch, which starts the continuous-current transformer as a series motor, the fields being feebly magnetised by a few turns of series winding carrying the high-pressure current. A circular resistance switch is provided, by which a considerable resistance is put in circuit at first, and is gradually altered as the armature gets up speed. When it begins to run, it excites its own shunt coils; and although, as a series motor running free, it would acquire a dangerous speed if the current were not held in check by the resistance, the shunt field soon attains its full strength, and the speed is automatically kept down to the normal 500 revolutions per minute, although the machine is running idle.

In order to put the generating circuit on to the supply network, an ingenious magnetic switch is used. A small switch at



the switch station is momentarily closed, and this short circuits the pilot voltmeter and allows a few amperes to pass through a large ironclad solenoid coil, which is always in the voltmeter circuit. This is represented diagrammatically in the figure by I, the thin lines representing the pilot wires. The core and iron disc which form the armature of the solenoid carry two pawls, which engage with a ratchet wheel. With the up stroke of the armature one pawl pulls a tooth, and with the down stroke the other pawl pushes a tooth. This movement of the ratchet wheel brings a cam *t* to bear on a large double switch, T and thus connects the transformer to the supply mains. The circular resistance switch which was used for controlling the starting current, can be pushed over beyond the zero point, to put coils of small resistance, but capable of carrying the whole current, into circuit, to control the voltage. An automatic cut-out carrying the whole low-pressure current is provided. This is represented by X in the diagram. In the event of heavy short-circuit the armature *x* is lifted, and this, striking a tooth of the cam wheel, breaks the connection between the dynamotor and the supply network. When the load has fallen to such a point that the feeding of the supply mains by any one secondary generator is no longer necessary, the attendant closes and opens the short-circuit switch, causing the ratchet wheel to move round; and the cam, passing forward, releases the main switch. Before thus breaking the circuit, the dynamotor is slowed down by introducing a resistance in the high-pressure circuit until the speed drops to such a point that the ammeter shows that no current is passing into the mains. The switch can then be opened without sparking. The brushes on the dynamotors give no trouble, and do not require to be shifted, as the reactions of the two windings neutralise each other.

In the daytime, one of the dynamotors is used to charge the batteries at Broad-street, and these take up the load after midnight. The supply is being taken up in an encouraging manner, and five 15-ampere Brockie-Pell arc lamps are being tried for street lighting. The low-pressure network consists of Callender cables armoured with steel tape. The progress of this station will be watched with great interest, as an important example of sub-station supply with continuous currents. Although the working of the magnetic switch cannot be described in a few words, it is not a complicated piece of apparatus, and it is most substantially made. The work seems to have been carried out very carefully and methodically, and everything looks favourable to successful operation.

TEST OF TWO 6,500-WATT WESTINGHOUSE TRANSFORMERS.*

Before giving any of the results of the tests I have made with your transformers it will be well to explain the methods of experiment adopted. The instantaneous value at any epoch in the period of the difference of potential between any two points of a circuit in which the potential difference is varied periodically is made effective on the measuring instrument by means of a rotating contact-maker attached to the shaft of the alternate-current generator. This contact-maker was constructed for the King's College laboratory by Messrs. Siemens Brothers. It makes contact once in each revolution for a period of about three-quarters of a degree, and breaks it for the rest of the revolution. It is entirely insulated, and so can be

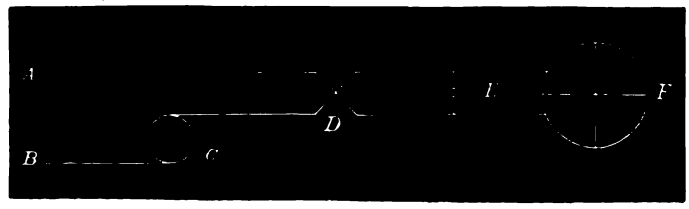


FIG. 1.

connected to any part of any circuit. The position of the contact can be varied, and the variations be read off on a graduated circle of 13½in. diameter divided into degrees, and by estimation the variation can be read to one-tenth of a degree. The two points between which it is desired to measure a potential difference are connected through the contact-maker to a condenser and a quadrant electrometer as shown in Fig. 1, in which A and B are the points, the potential difference of which at a stated epoch is to be measured, C the revolving contact-maker, D the reversing switch of the electrometer, E the condenser of which the capacity can be varied, F the quadrant electrometer. It is evident that the quadrant electrometer will give a reading proportional to the potential difference of A and B, when C makes contact. If there were no leakage it would at once give this potential. It is to obviate the effect of leakage that the condenser is introduced, and the amount of the effect was determined by varying the condenser, thus:—When the condenser had capacity 1, 0·5 and 0·2 microfarads the readings of the electrometer for a given potential difference of an alternating current at the position in the period of maximum electromotive force were 138, 136, and 132 respectively. The rate of loss of potential will be proportional to the reciprocal of the capacity, whence we at once infer that the true reading, if insulation were perfect, would be 139½, and hence the readings are always corrected by adding 1 per cent. When the potential difference was too great for the electrometer it was reduced in any desired ratio by two considerable resistances introduced between the points

* A report made by Dr. John Hopkinson to the Westinghouse Electric Company.

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to be measured in the usual way, thus (Fig. 2). The potential difference may, of course, be measured in other ways. An ordinary voltmeter may be placed between A and B, in which case it must be standardised with the contact-breaker in circuit; and it will depend for its constant on the duration of the contact, which may vary. Further, it gives, not the difference of potential at any definite epoch, but the mean difference for the whole time of the contact. The condenser may be used and its potential be measured by discharge through

Fig. 2.

a galvanometer; this is open to the objection that if there be any leakage the result will depend on the time at which the contact is broken by the condenser key in relation to the time at which it was made by the revolving contact-maker. Lastly, a Clark cell may be used, by a method which Major Cardew pointed out to me, thus (Fig. 3), the resistance being adjusted till there is no deflection. This is open to the same objection as the first, namely, that it gives the mean of the potential differences which occur during the contact. By making use of the first-mentioned method, we have the means of measuring accurately any potential difference at any epoch of the period, and of knowing the epoch.

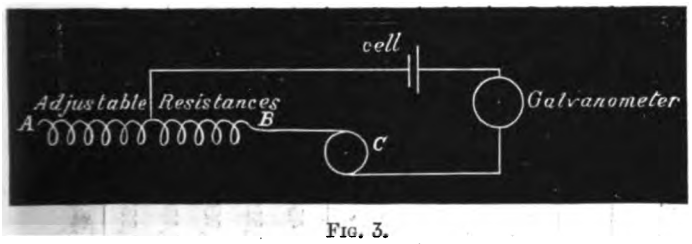

Fig. 3.

For these experiments, two transformers intended to be identical were available, each transforming between 2,400 and 100 volts. It was most convenient on account of the resistance available to couple these transformers up from 100 to 2,400 in the first or No. 1 transformer, then down from 2,400 to 100 in the second or No. 2 transformer, and to take up the energy from the second in a non-inductive resistance. The arrangement is thus (Fig. 4).

The obvious way of determining the efficiency of the combination would be to measure, at various epochs of a half period, the potential differences of the terminals of the machine and

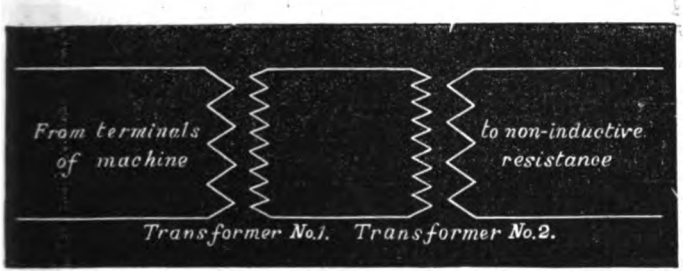

Fig. 4.

the current passing in the No. 1 transformer; in like manner, at the same epochs, to measure either the potential differences or the current passing to the non-inductive resistance, thence to deduce the power supplied to the first transformer and taken from the second. This would be open to certain objections; we are comparing two nearly equal magnitudes and desire their ratio, the ratio will be afflicted with the full error arising from an error in the determination of either magnitude; and such errors may be material, as the observations are not simultaneous, and conditions may change between one series of observations and another. These objections are avoided by the method adopted. The current from No. 2 is observed at certain epochs, the difference of current between No. 2 and No. 1, and the difference of potential difference of No. 2 and No. 1, at the same epoch. These give the currents and potentials of No. 1 at the same epochs as the corresponding determinations of No. 2, and the difference will only be afflicted with the

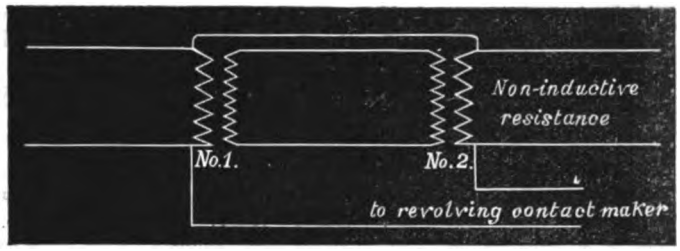

Fig. 5.

proportion of error of those differences. For example, suppose the efficiency of the combination were 90 per cent., and the possible error of determination of power 1 per cent., our result might be anything from 38 per cent. to 92 per cent. if made in the obvious way, but if made by differences the maximum loss would be 10·1 per cent., and the possible least determination of the efficiency would be 89·8 per cent. The method is essentially similar to the method I described* and subsequently used for testing dynamos. The measurements for difference of potential differences are made as in Fig. 5. For current difference (Fig. 6), where G is a known small non-inductive resistance, the two currents will, of course, slightly disturb each other; but this is readily allowed for in the calculations.

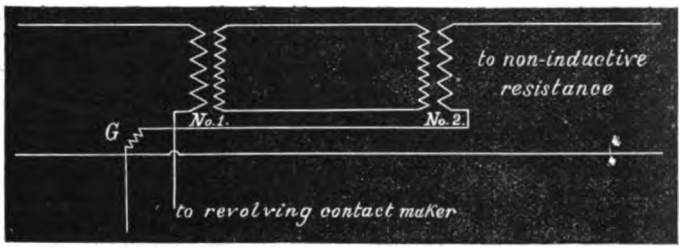

Fig. 6.

Another method would be to couple them thus (Fig. 7), G_1 and G_2 being equal non-inductive resistances. This arrangement is quite free from disturbance, but requires two resistances adjusted to exact equality. A single transformer can be tested in the same way, though, in this case, reliance must be placed upon resistances to reduce the current of the low

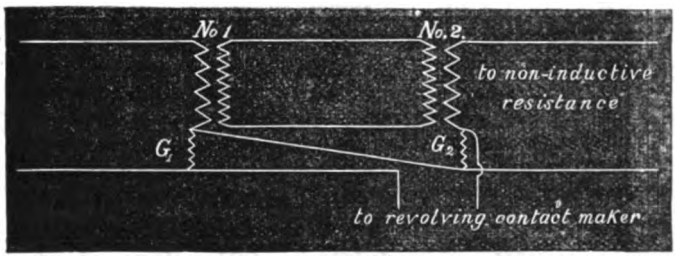

Fig. 7.

potential coil, and to reduce the potential of the high potential coil in the ratio of the number of windings in the two coils.

The current was throughout generated by a Siemens alternator with 12 magnets, run at a speed between 830 and 840 revolutions per minute, which gives a frequency of 5,000 per minute, or 83 to 84 per second.

* "Proceedings of the Institution of Civil Engineers," Vol. LXXXIII., p. 235; and "Transactions of the Royal Society," Part I, p. 347 (1886).

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Table II.

Leads of exploring brush on divided circle.	Current No. 2. Thick coil.			Current No. 1. Thick coil.					Mean of current in Nos. 1 and 2. Thick coils.	Potential No. 2. Thick coil.		Potential difference No. 1. Thick coil.					Mean of potential in Nos. 1 and 2 thick coils.	Watts supplied to No. 1.	Watts given out by No. 2.	Loss by resistance, and probably waste field.		Loss by hysteresis and local currents.	Difference of potential due to waste field.
	Observed deflection.	Corrected deflection.	Amperes.	Current difference. Thick coils, Nos. 1 and 2.				Amperes.		Volts.	Square of volts $\sqrt{\text{mean}^2} = 104$.	Potential difference. Thick coils. Nos. 1 and 2.			Volts.	Square of volts $\sqrt{\text{mean}^2} = 107{\cdot}4$.					Resistance.	Losses unaccounted for, probably waste field.		
				Observed deflection.	Corrected deflection.	Volts.	Amperes.					Observed deflection.	Corrected deflection.	Volts.										
267	2·5	2·5	+ 0·6	189·5	189·0	+ 3·7	− 2·9	− 2·3	− 0·8	+ 5·6	31	315·0	308·0	+18·2	+ 23·8	566	+ 14·7	− 55	+ 3	0·02	− 14·62	− 42·6	+18·2
270	65·0	65·0	+16·0	77·0	77·0	+ 1·5	− 1·2	+14·8	+15·4	+ 51·9	2,694	278·0	273·0	+16·1	+ 68·0	4,624	+ 60·0	+1,006	+ 830	8·7	+239·2	− 72·0	+15·5
273	108·5	108·5	+26·7	28·0	28·0	− 0·6	+ 0·4	+27·1	+26·9	+ 83·6	6,989	196·5	195·0	+11·5	+ 95·1	9,044	+ 89·3	+2,577	+2,232	26·6	+282·7	+ 35·7	+10·5
276	145·0	145·0	+35·6	99·0	99·0	− 1·9	+ 1·5	+37·1	+36·3	+110·3	12,165	99·0	197·2	+11·6	+121·9	14,860	+116·1	+4,523	+3,927	48·5	+372·5	+174·1	+10·3
279	186·0	186·0	+45·7	152·5	152·5	− 3·0	+ 2·4	+48·1	+46·9	+141·1	19,910	203·0	201·2	+11·9	+153·0	23,405	+147·1	+7,359	+6,448	80·9	+477·2	+353·0	+10·2
282	205·0	203·2	+49·9	186·0	186·0	− 3·7	+ 2·9	+52·8	+51·3	+153·6	23,592	61·0	61·0	+ 3·6	+157·2	24,710	+155·4	+8,300	+7,665	96·8	+ 87·9	+450·6	+ 1·7
285	184·0	184·0	+45·2	203·0	201·2	− 4·0	+ 3·1	+48·3	+46·7	+138·5	19,181	73·0	73·0	− 4·3	+134·2	18,009	+136·3	+6,482	+6,260	80·3	−281·3	+422·5	− 6·0
288	154·0	154·0	+37·8	220·0	218·0	− 4·3	+ 3·4	+41·2	+39·5	+114·9	13,202	75·0	75·0	− 4·4	+110·5	12,210	+112·7	+4,552	+4,343	57·5	−231·3	+383·0	− 5·9
291	123·0	123·0	+30·2	238·5	235·5	− 4·6	+ 3·6	+33·8	+32·0	+ 90·6	8,208	126·5	126·5	− 7·5	+ 83·1	6,904	+ 86·9	+2,808	+2,736	37·7	−277·7	+312·8	− 8·7
294	67·7	67·7	+16·6	237·0	234·0	− 4·6	+ 3·6	+20·2	+18·4	+ 47·7	2,275	252·0	248·5	−14·7	+ 33·0	1,089	+ 40·3	+ 666	+ 792	12·5	−283·0	+145·1	−15·4
											108,247					115,424		38,218	35,236	449·5	371·6	2,162·4	
																		92·2%					
																		298·2			298·3		

Table IV.

Leads of exploring brush on divided coil.	Current No. 2. Thick coil.			Current No. 1. Thick coil.					Mean of current in Nos. 1 and 2. Thick coils.	Potential No. 2. Thick coil.		Potential No. 1. Thick coil.					Mean of potential in Nos. 1 and 2. Thick coils.	Watts supplied to No. 1.	Watts given out by No. 2.	Losses by resistance, and probably waste field.		Loss by hysteresis and local currents.	Difference of potential due to waste field.
	Observed deflection.	Corrected deflection.	Amperes.	Current difference. Thick coils. Nos. 1 and 2.				Amperes.		Volts.	Square of volts. $\sqrt{\text{mean}^2} = 90{\cdot}9$	Potential difference. Thick coils. Nos. 1 and 2.			Volts.	Square of volts. $\sqrt{\text{mean}^2} = 98{\cdot}4$.				Resistance.	Losses unaccounted for, probably waste field		
				Observed deflection.	Corrected deflection.	Volts.	Amperes.					Observed deflection.	Corrected deflection.	Volts.									
270	59	59	+14·3	107	107	+2·1	−1·7	+ 12·6	+ 13·4	+ 21·3	454	355	345	+33·9	+ 55·2	3,047	38·3	695	304	6·8	+ 447·5	− 65·1	+33·4
276	256	252	+61·0	57	57	−1·1	+0·9	+ 61·9	+ 61·4	+ 80·7	6,512	256	252	+24·8	+105·5	11,130	93·1	6,530	4,923	142·8	+1380·2	+ 83·8	+22·5
282	427	410	+99·3	147	147	−2·9	+2·3	+101·6	+100·4	+130·2	16,950	142	142	+14·0	−144·2	20,790	127·2	14,650	12,928	382·0	+1023·5	+315·5	+10·2
288	381	369	+89·3	188	187	−3·7	+2·9	+ 92·2	+ 90·8	+116·1	13,480	59	59	− 5·8	+110·3	12,165	113·2	10,170	10,367	312·3	− 839·0	+328·3	− 9·2
294	207	205	+49·6	211	209	−4·1	+3·2	+ 52·8	+ 56·2	+ 62·4	3,893	266	262	−25·8	+ 36·6	1,340	49·5	1,933	3,095	99·3	−1420·3	+158·4	− 27·7
											41,289					48,472		33,978	31,617	943·2	591·9	820·9	
																		93·05%					
																		472·2			471·2		

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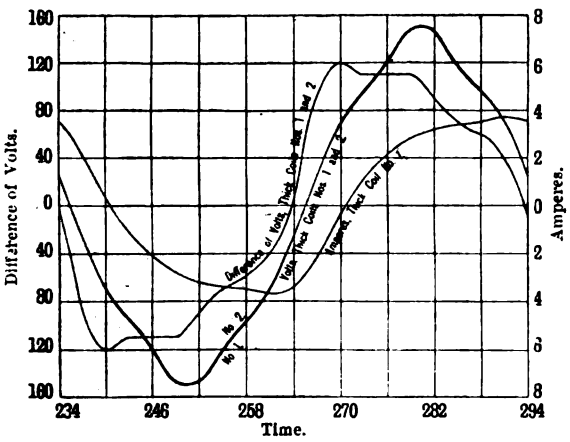
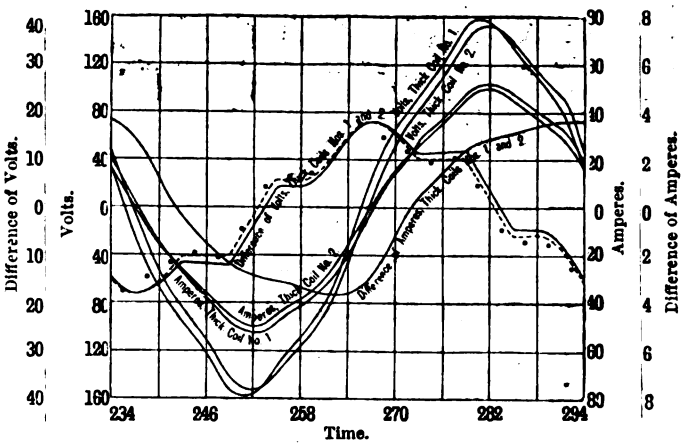
Table III.

Leads of exploring brush on divided circle.	Current No. 2 thick coil.	Current No. 1. Thick coil.		Mean of current in Nos. 1 and 2. Thick coils.	Potential No 2. Thick coil.		Potential difference. No. 1 Thick coil.			Mean of potential in Nos. 1 and 2. Thick coils	Watts supplied to No. 1.	Watts given out by No. 2.	Loss by resistance, and probably waste field.		Loss by hysteresis and local currents.	Difference of potential due to waste field.
	Amperes.	Current difference secondaries Nos 1&2 Amps.	Amperes.		Volts.	Square volts $\sqrt{\text{mean}^2}=98{\cdot}2$	Potential difference Thick coils Nos. 1 and 2. Volts.	Volts.	Square volts $\sqrt{\text{mean}^2}=104{\cdot}3$				Resistance	Losses unaccounted for, probably waste field.		
267	−15·0	−3·1	−18·1	−16·5	− 20·6	424	+31·2	+ 10·6	112	− 5·0	− 192	+ 309	10·4	− 525·1	+ 15·5	+31·8
270	+15·0	−1·6	+13·4	+14·2	+ 26·6	702	+29·7	+ 56·2	3,305	+ 41·3	+ 753	+ 397	7·6	+·414·1	− 66·1	+29·2
273	+38·5	−0·2	+38·3	+38·4	+ 63·0	3,969	+22·7	+ 85·7	7,345	+ 74·3	+ 3,282	+ 2,425	55·9	+ 815·7	− 14·9	+21·2
276	+57·1	+1·0	+53·1	+57·6	+ 91·8	8,427	+21·7	+113·5	12,880	+102·6	+ 6,595	+ 5,242	125·7	+1124·3	+102·6	+19·5
279	+75·2	+1·9	+77·1	+76·1	+120·2	14,440	+22·2	+142·4	20,280	+131·3	+10,980	+ 9,038	219·4	+1470·1	+249·5	+19·3
282	+88·8	+2·5	+91·3	+90·0	+141·6	20,050	+11·0	+152·6	23,285	+147·1	+13,930	+12,575	307·0	+ 683·0	+357·7	+ 7·6
285	+86·9	+2·8	+89·7	+88·3	+138·1	19,070	− 2·3	+135·8	18,440	+136·9	+12,180	+12,000	295·4	− 498·5	+383·3	− 5·7
288	+77·5	+3·1	+80·6	+79·0	+122·4	14,980	− 6·2	+116·2	13,502	+119·3	+ 9,365	+ 9,486	236·4	− 726·2	+369·8	− 9·2
291	+64·6	+3·4	+68·0	+66·3	+101·0	10,200	−11·8	+ 89·2	7,957	+ 95·1	+ 6,066	+ 6,524	166·5	− 948·8	+323·3	−14·3
294	+42·9	+3·5	+46·4	+44·6	+ 65·5	4,290	−24·2	+ 41·3	1,705	+ 53·4	+ 1,916	+ 2,810	75·4	−1154·6	+186·9	−25·9
						96,552			108,811		64,875	60,806	1,499·7	654·0	1,917·6	
											93·73%					
											406·9			407·1		

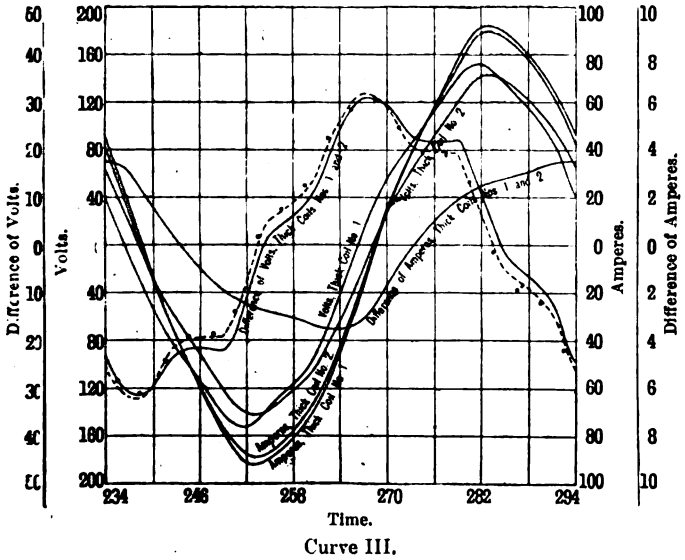
The first experiment tried* was with the two transformers coupled; but with No. 2 transformer on open circuit, or on nearly open circuit, for a high resistance for purposes of measurement was interposed between the terminals of the low-resistance coil of No. 2 transformer. The actual results are given in Table I., and are expressed in Curve I. Tables II., III., and IV., give the results for half-power, nearly full power, and full power, and the sets of curves of corresponding numbers give the results of the tables. In these tables the first column gives the position of the contact brush in degrees, so that 60 on this scale corresponds with a complete cycle. Three degrees are thus $\frac{1}{83{\cdot}3 \times 20}$ of a second. The second column of No. I. Table is the current in the thick coil of No. 1 transformer, as determined by the difference of potential at the two ends of a non-inductive resistance in which the current



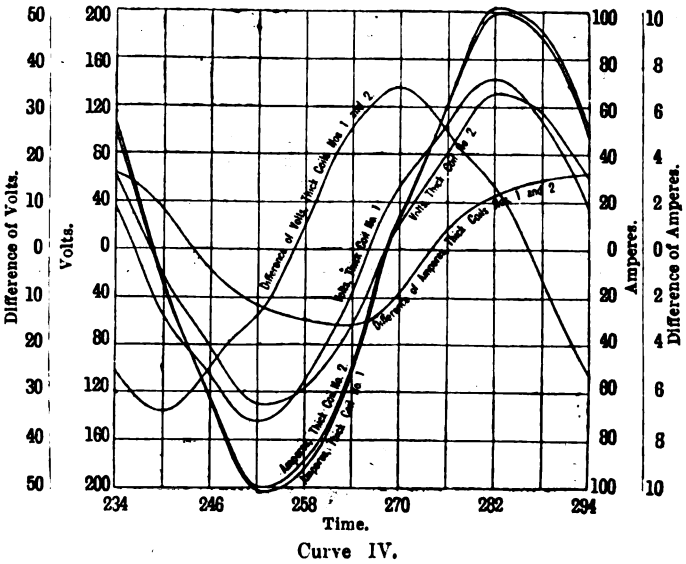
Curve I.



Curve II.



Curve III.



Curve IV.

* So far as I know, the first discussion of endless magnetic circuit transformers, based on the actual properties of the material, is in a note by myself (*Proc. Roy. Soc.*, Vol. XLII., and *Electrician*, Vol. XVIII., p. 421). Definite results were obtained by methods generally similar to those now used by Prof. Ryan (*Electrician*, January 10 and 17, 1890). The theory of transformers is well set forth by Prof. Fleming (*Electrician*, April, 22 and 29, 1892).

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passes. The third column is the potential difference of No. 2 transformer, a direct determination. The fourth column is solely for the purpose of determining the square root of the mean of the squares of the third column. This column is a direct determination of the difference of potential of No. 1 and No. 2 obtained in the manner explained with reference to Fig. 5.

Table I.

Leads of exploring brush on divided circle.	Current No. 1. Thick coils. Amperes	Potential No. 2. Thick coils. Volts.	Square of volts. $\sqrt{\text{mean}^2}$ = 101·1	Potential No. 1. Thick coils. P.D. Sec. Nos. 1 & 2 Volts.	Volts.	Square of volts. $\sqrt{\text{mean}^2}$ = 101·9	Watts supplied to No. 1.
267	- 2·2	+ 25·4	645	+ 0·9	+ 26·3	692	- 57·9
270	- 0·3	+ 70·2	4,928	+ 1·2	+ 71·4	5,098	- 21·4
273	+ 1·1	+ 95·3	9,082	+ 1·1	+ 96·4	9,292	+ 106·0
276	+ 2·1	+ 120·4	14,496	+ 1·1	+ 121·5	14,761	+ 255·1
279	+ 2·8	+ 147·7	21,816	+ 1·1	+ 148·8	22,140	+ 416·6
282	3·2	+ 147·2	21,668	+ 0·9	+ 148·1	21,935	+ 473·9
285	+ 3·4	+ 119·8	14,351	+ 0·7	+ 120·5	14,520	+ 409·7
288	+ 3·5	+ 97·8	9,565	+ 0·6	+ 98·4	9,683	+ 344·4
291	+ 3·7	+ 71·3	5,084	+ 0·4	÷ 71·7	5,140	+ 260·3
294	+ 3·5	+ 26·0	676	+ 0·3	+ 25·97	674	+ 90·9
...	...	...	102,311	...	...	103,935	2,282·6

The sixth column, is the deduced potential difference of the terminals of the thick wire of No. 1 transformer, being the sum of the third and fifth column. The seventh column, like the fourth, is merely for the purpose of determining the square root of the mean of the squares of column six, whilst the eighth gives the rate at which power is given out by or received by the pair of transformers.

(To be concluded.)

A NEW SYSTEM OF ELECTRIC PROPULSION.*

BY H. WARD LEONARD.

In the distribution of electricity from a power station for the operation of electric railways, the only commercial method to-day is by the use of a system of constant E.M.F. operating the motors in multiple arc with each other, and at the present time every consideration of economy and automatic regulation seems to indicate that the constant E M.F. multiple arc system will always be the best for such distributions.

In the use of electric energy by motors operating under conditions of varying speed and torque the best results as regards economy and regulation are obtained when the electric energy utilised has a voltage varying directly as the speed and a current varying directly as the torque ; for it is evident that under these conditions the electric energy required will be always proportional to the power developed.

If we could operate from the constant potential system a shunt-wound motor running at a constant speed and could interpose between this motor and the axle some device equivalent in its effect to an infinite number of different sets of mechanical gears, so that we could make use of any reduction desired, it would enable us while using a constant power to increase the torque as we decreased the speed and *vice versâ*, which is just what is desired in railway practice where the least torque is required when at full speed on the level and the greatest torque is required at the slow speed in starting and in operating on a grade. Numerous and very ingenious devices have been invented for accomplishing this variable mechanical reduction, but on account of the complication, noise and unreliability they have never proved successful.

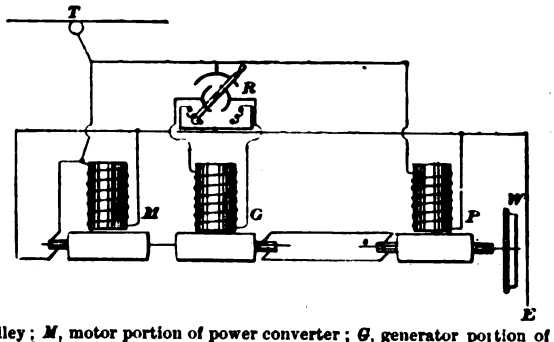
The writer has recently devised an electrical method of securing all the results which could be obtained from such a set of gears described, with a freedom from the noise, wear, complication and rigidity which such a set of gears would necessarily involve.

Following is a general description of the arrangement proposed, indicated by the Figure.

Each axle is driven by a gearless motor, either directly or by means of a connecting rod. The fields of these motors are excited directly from the constant E.M.F. of the line and independently of the armature circuit. Beneath the car and between the axles there is suspended a motor-generator, each armature winding being in a separate field. The motor portion of the motor-generator—which will, for convenience, be called the power converter—is shunt wound and connected just as a shunt motor is for use upon ordinary constant potential circuits. The field of the generator portion of the power converter has its field connected across the line and has inserted in it a regulating and reversing field rheostat. This field circuit is independent of the armature circuit. The generating armature of the power converter is in metallic connection with the armatures of the gearless propelling motors. It will be noticed that this circuit including the armature is a distinct and separate metallic circuit having no connection with the line in any way.

Suppose now that our shunt motor is running at full speed and that our controlling rheostat in the generator field circuit is at its central position, so that the generator field circuit is broken. Although the generator armature is being driven at full speed, it is revolving in a field having no magnetism except the residual magnetism, and hence produces practically no volts. Let us now move our controlling switch so as to place the generator field across the line, but with a resistance in series with the field, of ten times the resistance of the field coils. We now get a slight excitation of the field, and a development of volts at the brushes of perhaps 40 volts. This voltage will produce a current through the armatures of the driving motors dependent upon the ohmic resistance of this circuit only ; and hence, even at this low voltage, a large current will be produced, which, being in a field of full strength, will cause a torque sufficient to start the armature. The speed of the armature will, of course, be governed by the counter E.M.F., which its revolution produces in its strong field ; and hence, just as in the case of a shunt-wound motor, its speed will be practically constant so long as the E.M.F. supplied is constant.

If we now gradually increase the magnetic field of the generator by cutting out resistance by moving the controlling switch, we will gradually raise the E.M.F. of the armature circuit, and with it the speed of the driving motors. Since these armatures are revolving in a constant field, the torque they produce will be exactly proportional to the current in them, and the current will automatically



T, trolley ; *M*, motor portion of power converter ; *G*, generator portion of power converter ; *P*, the propelling motor for the car ; *R*, the regulating and reversing rheostat in field of G ; *E*, the connection to ground ; *W*, the car wheel.

flow exactly as is required to produce the necessary torque to maintain a speed such that the counter E.M.F. will approximately equal the E.M.F. supplied by the power converter. Thus it will be seen that the speed of the car will be dependent upon, and proportional to, the E.M.F. supplied by the power converter ; and the torque or tractive effort will be dependent upon, and proportional to, the current supplied by the power converter.

Let us suppose that 60 amperes flowing through the armatures in fully excited fields will produce a torque sufficient to move the load when upon a grade. It is evident from what we have seen that 40 volts from the power converter will produce this current. Hence, by an expenditure of 2,400 watts in the secondary circuit, or a total power, including field excitation, &c., of about 8 H.P., we can start a fully loaded car upon a grade.

Under the existing systems we would need the same 60 amperes in the same fully excited field, but would necessarily use the full voltage of 500 volts, and therefore consume energy represented by 30,000 watts, as against possibly 6,000 in this system. The current from the line in starting the car under ordinary conditions by this system would be about 12 amperes at 500 volts, instead of from 60 to 100 amperes at 500 volts.

In practice, the controlling switch lever can be instantly thrown from its central position to its extreme position for full speed. The field magnetism of the generator is rapidly increased, and consequently also its E.M.F., which in turn causes a gradual acceleration of the car.

The current in the armature circuit, and consequently the torque, is quite large in the beginning ; but the E.M.F. at this time is quite low, so that the total watts are low ; as the inertia is overcome and the counter E.M.F. begins to approximate to the impressed E.M.F., the current falls off, and finally becomes constant at an amount necessary to produce the torque required to

* Abstract of a Paper read at the General Meeting of the American Institute of Electrical Engineers, Chicago, June 6, 7, and 8, 1892.

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maintain the speed. The current from the line, and hence the power, gradually increases from zero to the amount required at full speed; but at no time, either at the start or during the acceleration, is the energy from the line greater than that required when we are operating at full speed. It will be noticed that the effect is the same as though we first operated through a set of gear wheels, giving an extremely great reduction of speed and then rapidly changed the ratio of gearing, until finally we operated at full speed with no reduction.

With our hypothetical gears we could, when running at speed, rapidly increase the ratio of gearing, so that the movement of the car would tend to drive the shunt motor faster and faster. This would convert it into a generator forcing current back into the system, which production of electrical energy would act as a brake, and gradually bring the car to rest.

Just so, if, while running at full speed, we suddenly place our switch-lever at its central position the field of the generator will gradually reduce the strength, and the counter E.M.F. of the propelling motors will soon exceed that of the generator. The momentum of the car will now be driving our gearless motors as generators, which will supply current to the former generator, operating it as a motor, causing it to drive the shunt motor coupled to it as a generator, which, in supplying energy to the line, will act as a brake, and smoothly but rapidly bring the car to rest by converting the energy stored up and represented in the movement of the car into electrical energy, which will tend to relieve the work at the central station. Similarly, a car descending a grade, and tending to accelerate in speed, can be made to move at any desired speed without the aid of any mechanical brake, and the energy represented by its falling weight will be converted into electric energy, and the car will become a moving feeder, supplying energy to assist the generators at the central station in the operation of other cars.

It will be evident from what has preceded that with this power converter system we can propel a car upon any practicable grade with a consumption of power no greater than is required to operate the car at full speed upon a level, by merely reducing the speed to the required extent.

In street railways of from five to ten cars, this is of great importance, for it means that we can equip a road with about 6 H.P. per car, as regards the engines and dynamos, and that our conductors can be reduced to about one-third of the amount at present necessary, for we will never require more than 20 amperes at the distant point, where to-day we have to provide for 60 amperes with the same loss and same initial E.M.F.

Under the rheostat system the plant is severely taxed when an unusual crowd must be moved from a certain point, and it is then, when it is of the greatest importance that no break-down should occur, that it usually does occur. With this power converter system we could, upon a five-car road, start up and move with perfect safety 10 or even 20 cars from the most distant point on the road, though of course at a reduced speed, but the crowd would be handled with perfect success, and without subjecting any portion of the plant to any unusual strain.

In the large cities it is no unusual sight to see an electric car moving at the slowest possible speed for perhaps several blocks. Perhaps 12 amperes are required to obtain the necessary torque. This at 500 volts is 6,000 watts. The power required for this slow motion by the proposed system would not exceed one-fifth of this amount.

The cost of car equipment will be increased by the cost of the motor-generator, but as a partial offset to this we have saved the rheostats, two expensive controlling switches and a complex system of wiring. Our motors having constant and fully-excited fields will operate absolutely without spark under all conditions. The control of the car will be entirely accomplished by a small switch and rheostat, handling never more than one half of an ampere, and occupying a space of one foot square and one inch deep over all.

As regards efficiency, we will have the advantages of the present system under all conditions. For long runs upon the level we will, by a suitable switch, connect the driving motors directly to the line and secure an efficiency of 90 per cent. for our motor.

As regards depreciation, we will have the advantage of no rheostats or controlling switches to burn out and with no sparking and no connection with the field circuit we will have the minimum liability of burning out armatures.

Leaving the car, let us now consider the line. It will be evident from what we have seen that we can reduce the amount of copper to one-half the present requirements, as we never will require the enormous currents at present called for in starting and upon heavy grades. Or, to put it in another way, with the existing conductors we could run twice as many cars as at present, with the same loss in the conductors.

Now, let us look at the generators and the prime movers, whether steam engines or water wheels. Under existing systems for roads of from five to ten cars it is necessary to instal about 20 I.H.P. (rated at ¼ cut-off) per car and about 16 kilowatts per car in generators. Also about 20 H.P. per car in boiler capacity. This large equipment is necessitated by the occasionally very large demand for power and the inefficiency consequent upon this. Under the proposed system it is not necessary to provide power in excess of 15 H.P. for any car under any conditions; and since in practice most of the cars will be operating at less power than this, we need only instal engine, dynamo and boiler capacity of 8 H.P. per car, instead of 20. Or, to express it another way, we can operate with existing boilers, engines and dynamos at least double the number of cars they can at present supply.

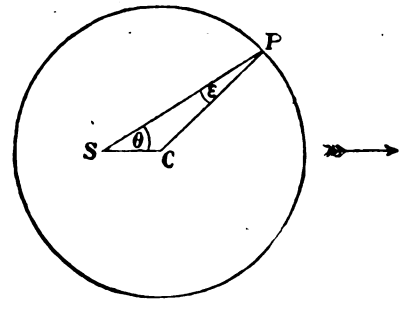
The features of the proposed system which seem, at first sight, to be very objectionable, are:—The increased cost of the car equipment, and the fact that we are adding an additional machine, having two fields, two armatures, and three bearings; but, as we have seen, there is only an apparent increase in the first cost, for the saving in the generators and distributing plant far exceeds the additional cost of the car equipment; and the use of the motor-generator for elevators, travelling cranes, &c., has demonstrated that, as regards the attention it requires and the depreciation it suffers, it has a marked advantage over the rheostat or commutated field used in the present methods of operation.

PHYSICAL SOCIETY.

At the ordinary meeting of this Society, held on the 27th ult., Prof. Oliver Lodge, F.R.S., read a Paper

"On the Present State of our Knowledge on the Connection between Ether and Matter."

Referring to difficulties arising in connection with the aberration of light, on the supposition that the ether is carried along by the earth in its orbits, Dr. Lodge referred to experiments of Klinkerfues, Sir G. Airy, and Hoek. The results of these tests were of a negative character, but appeared to show that surveying operations are unaffected by the relative motion, if any, of the earth and the ether. Other experiments by Arago, Maxwell, and Mascart lead to the conclusion that the ether is at rest with regard to the earth; but the apparently simple nature of aberration makes this view a difficult one to hold. Fizeau's well-known experiment on the effect



of moving water on the velocity of light, which has since been confirmed by the more accurate measurements of Michelson, practically establishes the truth of Fresnel's hypothesis—that only the excess of the ether which a substance possesses over surrounding space moves with the body. Looked at in another way, however, these experiments raise a difficulty, for, as all water is moving with the earth, light should be hurried or hindered according to the direction in which it passes through. This effect doubtless exists, but the result has never been experimentally detected, although carefully searched for by Babinet, Hoek, Jamin, and Mascart. From these and similar experiments the author is led to the conclusion that the ether is either stagnant or has a velocity potential.

In moving ether it was necessary to define a ray, and Lorentz's method is the best. Suppose C P represents the velocity of light (V) in still ether, and S C the velocity of the ether (v), then a disturbance originating at S will travel along S P, which is the direction of the ray, whilst C P is the wave normal. In the above figure,

$$\frac{\sin\varepsilon}{\sin\theta}=\frac{SC}{CP}=\frac{v}{V}=a,$$ the constant of aberration.

The velocity along the path of the ray is S P. Calling this velocity V', we have

$$V'=V\cos\varepsilon+v\cos\theta.$$

The path of a ray is determined by the time of journey being a minimum, and the formula

$$T=\int_A^B\frac{ds}{V}=\text{a minimum},$$

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is the equation to a ray, where A and B are the extremities, and ds an element of the path. If the ether be moving, V′ must be substituted for V, and we get

$$T' = \int_A^B \frac{ds}{V\cos\epsilon + v\cos\theta} = \text{a minimum.}$$

This integral can be written exactly—

$$T' = \int \frac{ds}{V}\frac{\cos\theta}{1-a^2} - \int \frac{v\cos\theta}{V^2(1-a^2)}ds = \frac{T\cos\theta}{1-a^2} - \int \frac{v}{V^2}\cdot\frac{\cos\theta}{1-a^2}\cdot ds.$$

The last term is the only one involving the first power of ether drift, and it vanishes in case there is a velocity potential; for, since $v\cos\theta\frac{d\phi}{ds}$, where ϕ is the velocity potential, it may be written $\frac{\phi_B - \phi_A}{V^2(1-a^2)}$; and so its value depends only on the end points and not on the path. If these points are the same, *i.e.* the contour is closed, it becomes zero, and reconciles all the experiments hitherto made. It must be admitted, however, that if a is not a constant, the question is again opened, but there is no reason to suppose it can vary in the same horizontal plane. If the medium be changed, V becomes $\frac{V}{\mu}$, and, in order to retain the same velocity potential in the changed medium, v must become $\frac{v}{\mu^2}$, which is Fresnel's law. Hence the author pointed out that the velocity potential condition includes Fresnel's law as a special case. It can, in general, be inferred that *no first order optical effect due to terrestrial motion can exist in a detectable form.* It is always compensated by something else. Quantities of the second order of magnitude must, therefore, be attended to. From the first equation above, it follows that

$$\cos\epsilon = \sqrt{1 - a^2\sin^2\theta},$$

and the time of journey in moving ether is given by

$$T' = T\frac{\sqrt{1-a^2\sin^2\theta}}{1-a^2},$$

where T is the time if everything were stationary. This is, in brief, the theory of Michelson's recent experiment. If the light travels along the ether drift, $\theta = 0$ and $T_1 = \frac{T}{1-a^2}$; whilst if $\theta = 90°$, $T' = \frac{T}{\sqrt{1-a^2}}$. Therefore the velocity along the ether drift should differ from that across the drift in the ratio of $\sqrt{1-a^2} : 1$. This point has been very carefully tested by Michelson, but nothing approaching to a quarter of the theoretical effect was observed. His negative result would seem to preclude any relative motion, even irrotational, and shows that the ether is at rest relative to the earth's surface. On the other hand, the author has recently made experiments on the influence of rapidly-rotating steel discs on the ether, which prove that the ether is not affected by the motion of contiguous matter to the extent of $\frac{1}{100}$th part of the velocity of the matter. Thus these two experiments are at present in conflict. Prof. Fitzgerald has suggested a way out of the difficulty by supposing the size of bodies to be a function of their velocity through ether.

THE PARIS-NEW YORK CABLE COMPANY.*

The Board of Directors nominated at the meeting of May 31st summoned the Executive Council of the Compagnie Française du Télégraphe de Paris à New York before a Judge in chambers in order to oblige that body to surrender its duties and hand over the management. The real Board of Directors taking its stand on the flagrant illegality of the above meeting, which was held contrary to the statutes by a group of shareholders, asked that the Judge in chambers should declare himself incompetent to deal with the matter. The Judge acceded to this request. The Board also summoned the self-elected Directors before the Tribunal de Commerce. The following is an extract from the summons, giving an epitome of the whole matter and of the claims of the real Board:—"The Board of Directors of the Compagnie Française du Télégraphe de Paris à New York had, in accordance with the statutes, called a general meeting of the shareholders for May 31st, in the Salle Kriegelstein, Rue Charras. A few days before the date fixed for the meeting a number of irregularities were discovered in the share register; irregularities of such gravity that they might have led to the annulment of the proceedings, and which already had given rise to protest on the part of some of the shareholders. Amongst these irregularities may be mentioned a distribution of shares to fictitious shareholders which would have vitiated the voting. The Board then decided on its own responsibility to call a fresh meeting for July 12th next, and to take the necessary measures to ensure the genuineness and regularity of the resolutions which will be put at this new meeting.

"It had come to the knowledge of the Board that a group of shareholders deemed themselves competent to meet on May 31, 1892, at the Salle Flaxland, and to hold there a sort of meeting, at which the shareholders present amused themselves by dismissing the Board of Directors and nominating a new Board; and the members of this new Board did not hesitate to summon the Executive Council to hand over the management and the moneys of the Company.

"These illegal proceedings having been very prejudicial to the plaintiff Company, there are grounds, the irregularity being proved, for condemning each individual member of the so-called Board, elected on May 31, 1892, to pay damages.

"For these reasons it was held that those who were summoned met on May 31, 1892, and proceeded to dismiss the Board of Directors and to nominate a new Board, without any right to do so, and in a manner contrary to the statutes, that MM. Magne, Bovillez, Bécue, Homberg (Georges), de Lussigny, Hurtado, and the Vicomte de la Moussaye et Tuck had no right whatever to intervene in the management of the Compagnie Française du Télégraphe de Paris à New York, and that each of them be condemned to pay 100,000frs. damages and costs. Also that the execution of this order should be carried out, notwithstanding opposition or appeal, all rights and means of action being reserved."

* From the *Moniteur Industriel* of June 11th.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—THURSDAY, JUNE 16TH.

Select Committee on the Telegraphs Bill.

On Thursday last week the Chancellor of the Exchequer presided over the Committee; and Mr. J. S. Forbes, Chairman of the National Telephone Company, gave further evidence.

Sir JAMES FERGUSSON put it to the witness that when he said Parliament was to some extent responsible for the very imperfect development of their system, he did not mean that Parliament was responsible in respect of the single-wire system, which was begun in the early days, and he must be himself sensible that except in cases where the traffic was small it was desirable to alter it.

The WITNESS said there was no doubt the efficiency of the system, and its expansion, had been greatly hampered for a number of years by a want of power in the hands of the telephone companies. In such crowded areas as London, Liverpool, and other large towns, a metallic circuit was absolutely necessary; that involved underground wires and interference with streets, and therefore more powers in respect to the opening of streets for the laying of wires. A Committee of Parliament in 1885 determined that the free development of the telephonic system was essential to the public convenience, and that it was inevitable that powers must be given; but they never have been given. Although that Committee reported in March, 1885, now in June, 1892, the companies were without a single addition to any powers they had ever had, and the powers which they possessed were only by sufferance. He was himself satisfied that the public must have the telephonic system expanded, and made as good as it could be. If every landowner, every householder, and every small local authority was to stand in the way and dictate terms they would not get that done.

Sir JAMES FERGUSSON: Your licence would be infinitely more valuable if you had those powers.

The WITNESS: No doubt; the public service would be more efficient and the public revenue greatly benefited by the expansion in the shape of royalties. In so far as the Bill was intended to increase their powers and facilities, they were in favour of it, and had themselves brought in a Bill which was based on the necessity of having those powers; but, as Sir James understood, that Bill had been kept back in view of the Government Bill. They had asked the Government to introduce an amendment into their Bill by which the companies would be permitted, in the first place, if they could, to make an agreement with the local authorities to lay underground wires, the Post Office stepping in if the Company should fail to make such agreements. It was greatly in the interest of the telephonic business in which they were to become partners, so to speak, that the Post Office should be able to take action. It was much better that it should be in the hands of the Postmaster-General than in the hands of half-a-dozen companies. As an instance of the necessity of some such powers being given, he said that the National Company had been for many months under contract to carry telephonic communication with Reading, notably under a contract with Messrs. Huntley and Palmer, and had agreed upon terms with individuals and a great number of local authorities, but one authority declined point-blank to come to any arrangement, and, consequently, they could not carry out the desired communication. The 160,000,000 messages which the Telephone Company carried were in the nature of conversations, and, of course, included replies as well as messages.

Sir JAMES FERGUSSON: Your proposal with regard to the purchase of the Company's trunk lines is that they should be purchased at the cost price as they stand in the Company's books, along with obligations as to wayleaves?—Yes.

Now you next touch upon a difficult point. You ask for the exclusive use of your present lines, in case of their purchase, and also that the Post Office should provide such additional trunk lines as the Company may demand.

The WITNESS said he should try to put that matter plain. They had at all events in their Company some regard for contract, and they had induced a great number of their subscribers to come on to their local

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exchange, in consideration, not so much of the convenience of the local exchanges, but of its connection with outside areas, and they had put up wires from time to time to meet that convenience.

Sir JAMES FERGUSSON: That being fully understood, I was going to ask you whether you do not recognise, in the case of the Post Office taking over your trunk lines, they will have at present no other exchanges to provide for, but that the extension will chiefly be in connection with your own business.

The WITNESS said that he felt that he must see that the subscribers were not damaged by any arrangement entered into with the Post Office. In reply to the Chairman he said that he qualified his statement that he would be willing to receive the book value of the trunk lines, by saying that, in some shape or other, they should receive an equivalent for the unearned increment of the 19 or 20 years that yet remained of the term of their licence, which he suggested should be in the shape of an extended rm.

Mr. WALLIS, a Director of the New Telephone Company, said that his Company were willing to enter into the Government scheme on certain conditions. He was perfectly convinced that the Government proposals would be a great benefit to the country.

Mr. WINTERBOTHAM, solicitor to the National Telephone Company, gave evidence as to the amendments that were required in the Bill from the point of view of his Company.

Mr. FRERE, representing the Bedford and Portman estates and other property owners, suggested that the Bill should be amended in regard to the matter of costs on the appeal before the Railway Commissioners, so that if an owner refused consent to the laying of lines on his property, and the refusal were appealed against, the Railway Commissioners should be bound to award costs against the beaten party. They also thought it unfair that where a private owner might have made certain terms with the companies, they should not continue to have the advantage of the bargain which they had made. The owner might have given his consent to the placing of a wire on his property on condition of receiving a rental of £5 or £10 a year, but under the Bill that was an arrangement which might be upset.

Sir JAMES FERGUSSON said that might have been a bargain imposed upon the Telephone Company which had no statutory rights, such as the Post Office had or desired to have. On the Post Office acquiring the trunk lines surely it might be allowed to reopen such a previous agreement made under great disadvantages with the Telephone Company, and this Bill would enable them to re-open it before a proper tribunal. The private owner might have extracted extreme compensation or conditions from the Company because the Company had no statutory position.

The WITNESS said that might be so, but to do so would be for Parliament to take away from them that which they had got by means of bargain.

Mr. BAKER (who said he represented 150 local authorities) said that if any alteration in Clause 5 relating to local authorities were contemplated, he should desire to place their case before the Committee.

The Committee consulted in private for some time, at the end of which

The CHAIRMAN announced that the Committee were of opinion that it was desirable and fair to the parties more or less interested in the Bill that they should know the decision at which the Committee had arrived. The Bill had been passed by the Committee substantially as it stood, with some amendments, which would be reprinted, so that the public might be able to see what changes had been made. The Chairman further stated that the Committee had also agreed upon a special report, which he proceeded to read, and which appeared in our last issue.

The Electric Railways.

Yesterday (Thursday) the Marquis of Waterford's Committee commenced the inquiry into the Baker-street and Waterloo scheme, the only opponents to the Bill being the Metropolitan and South-Eastern Railway Companies. In the course of the proceedings the latter Company were arranged with; and the Committee having intimated that they were satisfied with the evidence given by the promoters, the only point remaining was in relation to the manner in which the Baker-street Station of the Metropolitan Railway was affected, and clauses dealing with this point were considered.

LEGAL INTELLIGENCE.

Pink v. Electricity Supply Company for Spain (Limited).

This was an action for wrongful dismissal and consequent damages. The plaintiff was engaged by the defendant Company under contract to act as resident engineer in Madrid. Being unable to agree with the manager in Spain on technical matters, plaintiff, after an appeal to the Directors in London, offered to resign, but was thereupon dismissed by the manager. He returned to London under protest, and after attempting an amicable settlement, commenced the present action. The case was finally settled out of court, by the defendants paying three months' salary in lieu of notice, first-class travelling expenses, and all costs.

The Plaintiff asks us to state that he has received a letter from the defendant Company, in which the Directors regret the termination of the plaintiff's engagement with the Company, and recognised his endeavours in the Company's behalf while acting for them in Spain. They ascribe the differences with the manager in Spain as mainly due to the want of a common language. The plaintiff is further credited with the carrying out of important economies in the working of the Company's central station.

Atkinson v. Stephens, Smith and Co.

In the High Court, on Saturday and Monday last, the Lord Chief Justice and a special jury had before them an action brought by an apprentice to recover his premium of £100, which had been paid to the defendants under an agreement dated November 9, 1889. The plaintiff's case was that, wishing to become an electrical engineer, he went to the defendants' works at Cuba-street, Millwall, and an agreement was entered into between them whereby he was to pay £100, and the defendants undertook to take him into the electrical department of their works for three years, and to teach and instruct him in electrical engineering in all its branches, special attention being given to imparting instruction in mechanical drawing, testing, and practical knowledge of electric motors and dynamos. The plaintiff was to attend at the works from 9 a.m. to 5 p.m., and was to receive 8s. a week salary. When the plaintiff entered upon his duties the defendants told him to watch the workmen doing their work, and they also set him to do mechanical work connected with electric motors. The plaintiff objected to this class of work, desiring to be taught the theoretical part of the work. The plaintiff also complained that there was not sufficient electrical work going on to teach him his profession.

Evidence was called for the plaintiff, including two other apprentices at the defendants' works, who stated that there was not work enough there to keep them sufficiently employed.

On the other hand, for the defendants, it was proved that during the time the plaintiff was with them they had a great number of electrical jobs on hand, quite sufficient to give the plaintiff all necessary instruction, but that the plaintiff only attended from three to five hours per week; they also contended that they only undertook to teach practical work, and not the theoretical science of electricity.

In the result, the jury returned a verdict for the defendants.

Denby v. Scott and Mountain (Limited).

In the Second Division of the Court of Session (Edinburgh) on Wednesday last week, the Lord Justice Clerk and Lords Young, Rutherfurd Clark, and Trayner gave judgment in the above action.

In the Outer House Lord Kyllachy, as previously reported (*The Electrician*, Vol. XXVIII., p. 152), gave judgment on December 9th last in the action by John Denby, stereotyper and electrotyper, 4, Swinton-row, Edinburgh, against Ernest Scott and Mountain (Limited), engineers, Close Works, Newcastle-upon-Tyne, for £500 damages for alleged breach of contract, he having been supplied with a dynamo machine for his business as an electrotyper, which, he averred, was unfit for the purpose for which it was furnished. Lord Kyllachy, after proof, assoilzied the defenders with expenses, holding that the pursuer had not proved that the dynamo was disconform to contract. Against this judgment the pursuer reclaimed to the Second Division. On the reclaiming note the pursuer asked leave to lead additional proof on a condescendence of *res noviter*, in which he averred that since the proof he had ascertained that certain tests were made of the machine in the defenders' works at Newcastle before it was supplied to him, which would demonstrate that the machine was not suitable for electrotyping at the normal speed of his engine. The additional proof was led before Lord Rutherfurd Clark, on March 12th, when it was proved that the machine was now in Messrs. Chambers' works in Edinburgh. On being tested it gave exactly the same when tested at Newcastle, and further that on being turned to electrotype the work it produced was first-class. The Division to-day refused the reclaiming note, assoilzied the defenders, and found them entitled to further expenses.

JUDGMENT.

Lord YOUNG, who gave the leading opinion, said it was much to be regretted, looking at the expense involved in the bringing of the action, that the pursuer had given an order for a machine before he knew how to work it. His lordship was of opinion that if the pursuer intended to reject the machine as disconform to contract, it was not done timeously, but on the proof his lordship said the evidence disclosed that the defenders had supplied the machine contracted for, and that it was perfectly suitable for electrotyping.

The other Judges concurred.

CORRESPONDENCE.

THE CITY AND SOUTH LONDON ELECTRIC RAILWAY

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the present Session of Parliament no fewer than six Bills have been introduced authorising the construction of new underground railways in London to be worked electrically, or the extension of those for which Acts of Parliament have already been obtained. Three of these Bills have passed through the House of Commons, and are in an advanced stage in the Upper House. The present time, therefore, is opportune for drawing attention to the results which have been attained with electric traction on the only railway in the world on which it has been adopted on an extensive scale, and the working of which during the eighteen months it has been open for public traffic is the basis upon which the promoters of the present

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schemes found their application for Parliamentary powers, and from which they must in the future seek the confidence of the public. That the City and South London line has been a success in the system of traction adopted is conclusively shown by the mere fact of the present schemes being brought forward, and has moreover been abundantly proved by the evidence given before the Joint Committee of both Houses appointed to consider the proposed lines from the point of view of their general public utility, and also by the evidence given as the Bills passed through Committee in the Lower House; but, as you yourself point out in a recent editorial note, no authentic information has been forthcoming as to the actual results achieved, nor any explanation of any shortcomings in its working which must be obviated in the future.

The limits of a letter do not permit the discussion of the engineering features of the electrical plant adopted; but as my firm designed and constructed the whole electrical equipment of the railway, the present occasion is not inopportune either in time or place for me to give a brief account of the history of the first year's working and of the results achieved, leaving for some other occasion a discussion of the technical details.

The City and South London Railway Company, then known as the City of London and Southwark Subway Company, obtained its first Parliamentary powers in 1884 for the construction of a subway from King William-street in the City to the Elephant and Castle in Southwark. The success, however, of Mr. Greathead's beautiful system of constructing the tunnels, now familiar to all interested in engineering matters, had been so conspicuous that the Directors obtained powers in 1887 for an extension to the Swan Inn at Stockwell. Further powers have since been obtained for an extension southwards to Clapham, but this portion of the line has not yet been constructed. It was originally intended that the Subway should be worked on the cable system, and contracts were actually arranged for this purpose, but the progress of electrical traction in the interval made it necessary to reconsider the system of traction to be adopted. The Bessbrook and Newry Tramway (more correctly described as a railway) had been equipped with electrical plant by Messrs. Mather and Platt, and had been running with perfect regularity for three years. The weight of the trains on this line were but little less than the weight of the trains proposed for the South London line, and the cost of haulage had been proved not to exceed 4d. per train mile, although the mileage was small, and consequently fixed expenses high in proportion. The success attending the Bessbrook line induced Messrs. Mather and Platt in 1888 to approach the Directors of the City and South London line, and to make definite proposals to them for working their line electrically, instead of by cable. After long consideration the cable system was finally abandoned, and Messrs. Mather and Platt's scheme accepted in its entirety. Their proposal was accompanied by an offer to work the line for a limited period or to guarantee the cost of traction for two years. The locomotives were to be designed for drawing trains consisting of three carriages accommodating 100 passengers, and weighing 4¼ tons each, and the generating plant was to be sufficient for working a service of 20 trains per hour. A contract was entered into with Messrs. Mather and Platt, in January, 1889, and their guarantee accepted that the cost of haulage, exclusive of driver's wages, should not exceed 3½d. per train mile for the maximum service proposed, viz., 384,800 train miles in the half-year, and according to a sliding scale, if the mileage were more or less, increasing up to 7⅛d. per train mile for 188,666 miles, the actual mileage accomplished.

The works were completed in November, 1890, and on November 4th were formally inaugurated by the Prince of Wales, accompanied by the late Duke of Clarence. On December 18, 1890, the line was opened for public traffic; and has now completed eighteen months' running. During this time Messrs. Mather and Platt's locomotives have run more than 500,000 miles, and have provided for a traffic of more than 7,000,000 persons; but this statement alone does not fully represent the work which has been demanded from them. Owing to the carriages being made stronger and heavier than originally designed, the actual weight of each carriage being 7 tons instead of 4¼ tons, the weight of the loaded trains was increased to 42 tons, or more than 40 per cent. heavier than the trains for which the locomotives were designed. Of this great increase in the loads which their locomotives were to draw, Messrs. Mather and Platt had no intimation until after all the locomotives were constructed and delivered, and arrangements had been made for the opening of the line. Under such unexpected circumstances the locomotives have at times been overstrained, and delays to the traffic resulted, and the wear and tear has proved somewhat greater than originally anticipated, yet the record of work done by the electric locomotives in comparison with the work done by steam locomotives is extraordinary. Leaving out of consideration one of the locomotives of special type made for the purpose of testing its comparative efficiency, the average mileage made by the remaining 13 locomotives during the first year of work exceeded 27,000 miles. On the Metropolitan District Railway the yearly average of their locomotives appears to be less than 20,000 miles. The cost of working has proved equally satisfactory. Although the formal guarantee of Messrs. Mather and Platt was not taken up on account of the carriages failing to comply with the specification upon which they were requested to base their calculations, yet their estimate of cost has been abundantly justified. During the second six months of working, according to the published half-yearly accounts, the cost of locomotives and generating power, including wages, repairs, and renewals, was £6,199 for a mileage of 188,666, or less than 8d. per mile. If allowance be made for the driver's wages, which were excluded from the original estimate, this is equivalent to about 5½d. per train mile, 25 per cent. less than the amount guaranteed by Messrs. Mather and Platt, although the weight of the trains had been increased 40 per cent. These facts are the more striking when the difficulties of adequate and regular inspection of the rolling stock of a line entirely underground are considered, difficulties which do not obtain in the case of any ordinary railway; and when it is further remembered that the entire system of working was novel, to which the employés of the Company were unaccustomed, and for which they had received no special training.

Under the able management of Mr. Basil Mott, the Company's engineer, and Mr. T. C. Jenkin, the general manager, it is probable that the working expenses will be still further reduced, while the mileage and traffic receipts are being steadily increased.

The distinguishing feature of Messrs. Mather and Platt's locomotive is that the armature is constructed directly upon the axle, and the magnets supported partly upon the axle and partly upon the frame. Probably this design, obviating all gear, and reducing the mechanism to the simplest elements, has contributed more than anything else to the successful working. For the heavier trains which will be required for the working of the new lines there will be no difficulty in designing heavier and more powerful locomotives on the same principle. In the schemes now under consideration, Mr. Greathead is proposing larger tunnels, 12ft. in diameter, instead of 10ft., as in the case of the City and South London line. This will greatly facilitate the construction of larger locomotives and more commodious and comfortable carriages, which are the chief points necessary to ensure the success of the new undertakings.—Yours, &c.,

EDWARD HOPKINSON.

Salford Iron Works, Manchester, June 21, 1892.

CRYSTAL PALACE EXHIBITION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Do you happen to know if there is any reason why the jury appointed to examine, &c., the exhibits at the Crystal Palace should decline to undertake the examination and testing of meters?

There is probably no subject of greater interest and importance just now than the means by which consumers are to be charged for the current they take. It seems incomprehensible that the jury should decline to concern themselves with it.—Yours, &c.,

S. Z. DE FERRANTI.

[This is referred to in our Notes.—ED. *E.*]

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RUNNING ALTERNATORS IN PARALLEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the correspondence in your paper on this subject it may interest your readers to know that within a few months of the establishment of this station three years ago, we have been in the habit of running regularly with the Mordey-Victoria alternators in parallel. Whenever the load exceeds that of one machine we run in this way, and have never experienced any trouble.

As a matter of fact, we could not run in any other way if we wished to do so, as we have only one main into the town, and the switchboards are arranged on the standard plan of the system, by which no provision is made for any other mode of working. We may add that our alternators are two of 37·5 kilowatt, and three of 75 kilowatt, and that the engines are also of the Brush Company's make.—Yours, &c.,

JAMES SHEPHERD, Works Manager,
The Bournemouth and District Electric Supply Company.

Bournemouth, June 20, 1892.

TRADE NOTES AND NOTICES.

Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

TENDERS INVITED.—The Secretary of State for War invites tenders for the purchase of Matheson's ebonite connectors and Morse's recorders, now lying at the Royal Arsenal, Woolwich, where they can be viewed, and forms of tender and all information can be obtained on application to the Commissary-General of Ordnance, any week day between 10 a.m. to 1 p.m. and 2 p.m. to 4 p.m. (Saturday afternoons excepted). Tenders are to be sent in to the War Office, Pall Mall, S.W., by 12 o'clock on Monday, 4th July, addressed to the Director of Army Contracts. Further information is given in our advertisement columns.

——— The Gas Committee of the Manchester Corporation invite tenders for the electric wiring of the Town Hall. General conditions and specifications can be obtained on written application to Mr. C. Nickson, superintendent of the gas department, Town Hall, accompanied by a deposit of two guineas, and tenders must reach the Chairman of the Gas Committee by 10 a.m. on the 5th prox.

———Tenders are invited by the Huddersfield Corporation for the supply of an arc and incandescent plant at the Sewage Works. Specifications and forms of tender may be obtained from Mr. A. B. Mountain, the borough engineer, to whom tenders are to be delivered not later than Saturday, the 2nd prox.

———The Material Bureau of the Königliche Eisenbahn Direction, Hanover, invite tenders for 10,000 zinc and 7,000 copper elements, 78,800 kilogrammes of galvanised iron wire of various diameter, and 4,000 metres of 4mm. steel wire. Tenders are to be in by the 30th inst.

———The Director-General of Posts and Telegraphs of Roumania will on July 4th open such tenders as may be received by him for the supply of 10,000 large and 20,000 small porcelain insulators.

PLANT FOR SALE.—Messrs. Wheatley Kirk, Price and Goulty announce in our advertisement columns that they have for sale several engines suitable for electric light driving (including a very fine pair of new vertical Corliss engines, guaranteed to indicate 10,000 H.P.), two combined Willans engines and dynamos, about fifty dynamos and motors, a 100 I.H.P. Babcock-Wilcox boiler, and a small electric light installation, comprising a Crompton dynamo, 26 E.P.S. 11-L. glass cell accumulators, instruments, switches, &c.

NEW FIRMS.—Mr. Arthur Bergtheil (late manager of the Wenham Company's electrical department) and Mr. H. Wilson Young (formerly with Messrs. Clarke, Chapman and Co.) have commenced business as electrical engineers and contractors at 13, Walbrook, London, E.C.

——— Messrs. McInnes and Co. have commenced business as manufacturing electricians and electric light engineers at Magenta-street, Woodgate, Leicester.

VAUGHAN-SHERRIN ELECTRICAL ENGINEERING COMPANY (LIMITED). At meetings of the shareholders of this Company held on May 19th and June 10th, it was resolved and confirmed that the Company be voluntarily wound up, and that Mr. Septimus Hedges, 15, George-street, Mansion House, E.C., be the liquidator.

BANKRUPT.—A receiving order has been issued in the estate of Walter Philip O'Reilly, of Edgware-road, described as a manufacturing electrician.

DISSOLUTION OF PARTNERSHIP.—Messrs. Nicholson, Bolton, and Tyler, carrying on business at 100c, Queen Victoria-street, E.C., as electrical and mechanical engineers, have dissolved partnership so far as regards R. P. Bolton.

MR. WALTER LEAKE.—It is intended to adopt the electric light throughout St. Patrick's Training College, Drumcondra, Dublin. Mr. Walter Leake has been appointed Consulting Electrical Engineer to the College.

SADDLE STAPLES.—Staples with a saddle of vulcanised fibre which have been in use for some time are now being made by Messrs. Mosses and Mitchell. They should prove useful in electric bell and telephone work in dry places, since the fibre will prevent cutting of the wire by the metal. We, however, disagree with the use of vulcanised fibre for insulating purposes in electric light work, and with the use of staples for holding electric light wires. The mechanical qualities of vulcanised fibre are, of course, well known.

MESSRS. ERNEST SCOTT AND MOUNTAIN (LIMITED).—This firm have just completed an electric pumping plant for the North Seaton Colliery, the pumps being the largest of the kind that have yet been made.

MR. W. S. SARGEANT.—We learn that Mr. Sargeant has applied for a patent for an electric port, starboard and mast-head light in one fitting. Two switches are used, one controls the port and starboard light, and the other the light at the mast-head. It is stated that excellent results have been obtained from the tests to which this lamp has been put, and four are being made for use on electric launches now built or building.

MESSRS. ARTHUR B. GILL AND CO.—Mr. Arthur B. Gill, trading under the above title as an electrical engineer, of 36, Parliament-street, S.W., Eastdown Park, Lewisham, and Grove Park, has filed a deed of assignment of his property for the benefit of his creditors, the principal of whom are:—

Aërated Bread Company (Limited), London	£100	0	0
Beal (S.) and Co., London	29	0	0
Best and Lloyd, Birmingham	25	0	0
Buller, Jobson and Co. (Limited), London	65	0	0
Edison & Swan United Electric Light Co., London	80	0	0
Harris (J. F.) and Co., London	22	0	0
Hindley, E. S., Bourton	37	0	0
Henley's (W. T.) Telegraph Works Co. (Limited), London	312	0	0
International Publishing Co., London	32	0	0
Johnson and Phillips, London	33	0	0
Lawrence, H. E., London	55	0	0
Nalder Bros. and Co., London	27	0	0
Peel, Captain Robert, Beckenham	3,806	0	0
Bankers' claim	431	0	0
And creditors under £20.			
Total	£5,418	15	1
Secured	416	0	0
Net assets	4,984	0	5

GRANGE SYNDICATE (LIMITED).—The following are the principal creditors of this Company, now being wound up:—

Courtenay and Co., London	£150	0	0
Elliott and Co., London	39	3	6
Hollick, William, London	21	0	0
Hopkinson, Dr. J., London	39	19	6
Rawson, F. L., London	192	16	4
Woodhouse and Rawson United (Limited), London	11	19	2
And other creditors under £20.			
Total	£520	4	3
Fully secured creditor	22	0	0
Liabilities on bills	34	0	0
Preferential creditors	27	1	11

NOT ELECTRICAL.—The Great Eastern Railway Company have just issued their annual list of farm houses and country lodgings in the counties served by the Great Eastern system, including Essex, Hertfordshire, Cambridgeshire, Suffolk and Norfolk. The list is in tabulated form and gives a quantity of information which will be found of the greatest possible use at this season of the year to those seeking health and change. This must be our excuse for calling attention to a publication not of an electrical character.

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PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

May 31, 1892.

10,303. W. P. CARSTARPHEN, Jun. London. Improvements in electrical reciprocating tools.

10,334. R. KENNEDY. Glasgow. Improvements in dynamo-electric generators and motors.

10,367. H. SANCHE. London. Improvements in connections and terminals for electric and other wires and cables.

10,388. E. FREUND and L. BRISTÖL. London. Improvements in secondary batteries.

June 1, 1892.

10,430. R. WOOD. Manchester. An improvement in electrical insulating sheet. (C. W. Jefferson and Rupert R. St. John.)

10,451. R. N. LUCAS, A. J. MAYNE, and A. G. NEW. London. An automatic switch for electric-current transformers.

10,456. H. H. LAKE. London. Improvements in the manufacture of conducting wires for electricity. (Madame V. Hannetelle, *née* Hortense Chapuis, France.)

10,466. Sir C. S. FORBES. London. An improved telephone combination.

June 2, 1892.

10,472. J. A. EWING. Cambridge. Improvements in apparatus for electrical and magnetic measurements.

10,477. W. W. HORN. London. An improved cut-off for electrical purposes. (J. P. Wooley, Canada.)

10,478. W. GRIERSON. Glasgow. Improvements in electric generators.

10,484. J. SAYERS. Derby. An improved method of regulation of the potential difference of electrical conductors.

10,520. A. V. BORCKXSEL. London. Improvements in and connected with electrical batteries.

10,524. A. H. S. DYER. London. Electrical insulating sheet.

June 3, 1892.

10,544. G. SACCO. London. The extra rapid telegraphic apparatus with inverted currents.

10,602. A. MYALL. London. Improvements in telephones. (W. S. Harrison, China.)

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

8,793. HANUSSE AND BORREL. Electrical signalling.

10,434. SINGER. Electric meters.

12,018. WILSON. Electrical gear for steering ships, &c.

12,491. BAKERS and others. Rheostats.

12,529. EDMUNDS. Distributing electric currents.

12,605. LAKE. (Lacombe and Co.) Electric batteries.

14,517. SIEMENS BROS. AND CO. (LIMITED). (Siemens and Halske.) Microphones.

15,337. MUIRHEAD. Electrical condensers.

1892.

2,488. TRIPPE. Electric lighting.

7,253. DUFFY. Generating electricity.

COMPANIES' MEETINGS & REPORTS.

Western Counties and South Wales Telephone Company (Limited).

An extraordinary general meeting of this Company was held on Tuesday afternoon at the Grand Hotel, Bristol, to consider resolutions for the amalgamation of the Company with the National Telephone Company (Limited). Mr. C. Nash, Chairman of the Directors, presided.

Mr. H. F. LEWIS (General Manager and Secretary) having read the convening notice,

The CHAIRMAN moved the first resolution, as follows:—

"*That the agreement submitted to this meeting, and expressed to be made between this Company and the National Telephone Company (Limited), for the amalgamation of the two Companies by a transfer of the business and property of this Company (with certain exceptions) to the National Telephone Company (Limited), be, and the same is, hereby approved.*"

One reason, he said, why it was most important that the Company should be united to the National was that they might have joint action. Seeing that five out of the six English telephone companies had been amalgamated, he thought it would be very undesirable for that Company to stand aloof. Joint action was desirable, among other things, in dealing with the Post Office, and in connection with the extensive changes that were now being introduced in telephone matters. They were on the eve, probably, of a revolution in telephone work. The Directors had made the best terms they could with the National, and they were unanimously of opinion that the shareholders would be doing right in confirming the provisional arrangement which had been made, and in this they were glad to know the great bulk of the shareholders agreed. It had been pointed out that 6 per cent., which was the dividend now payable on the National Company's stock, would yield £1. 13s. 4d. per cent. on their Company's shares if the proposed arrangement were carried out. This was more than they had paid up to the present time, and it was certainly more than they could expect to earn if the Company went on independently.

Mr. MARK WHITWILL seconded the resolution.

Mr. GEORGE WHITE referred to the letter which members of the Bristol Stock Exchange addressed to the Directors, expressing their opinion that there was no reason why the undertaking should be sold except upon proper terms, and the letter continued:—"Seeing that the present revenue of the Company exceeds the income which would accrue to the shareholders under the proposed sale, and that no return is being secured to the Company for its splendid future, we are of opinion that you will best consult the interests of the shareholders by refusing to sell the undertaking upon the present inadequate terms." To this the Directors replied that if the signatories of the memorial would give a firm offer to raise, say, £100,000 upon Second Preference shares, at such a rate of interest as would not exceed the earning power of the Company, the Directors would submit the proposal to the National Company, and suggest that they give to the Western Company an option of either accepting the terms of amalgamation now under consideration, or of raising additional capital from the continuation of the Company as a separate undertaking. In the opinion of the Directors, the reply further stated, it would be useless to propose the raising of capital without at the same time showing that it could be effected on reasonable terms. But what had happened? The Directors, instead of being prepared to discuss the matter, directly they received a letter from the members of the Stock Exchange saying "Yes, we will raise the money on reasonable terms," got out their notices sharply. He did not consider that was a proper way to deal with the question. Having thrown down the gauntlet, and asked if the members of the Stock Exchange were ready to find the money, and these gentlemen having replied, the Directors simply issued notices of the proposed sale to the National. The Directors ought to have taken time over the question and been prepared to discuss with the Stock Exchange the alternative proposals. In the letter from that body to the Directors there was a provision that the Board would have to be re-constituted, and if the Directors felt that that was a stumbling block, well and good. He moved the adjournment of the meeting for three weeks to enable the Directors to further consider their position.

Mr. McKNIGHT (Liverpool) seconded the amendment, and expressed the opinion that before any terms were discussed with the National Company ordinary shareholders ought to have had the option of finding the money necessary to carry out the business.

Mr. JAMES INSKIP, the Company's solicitor, referred to the agreement in existence between the two Companies, and said it contained a provision not only that the Company should not enter into an arrangement with the Post Office or any public department of the Government without the sanction of the National Company, but further, that whatever compensation was received should be divided between the Companies in such a manner as arbitrators should settle. In other cases the amalgamations had been with large Companies, not, as some shareholders might think, with small ones. This matter had not been rushed; the Directors had been attending to it for a long time.

In reply to a question, the GENERAL MANAGER said that nothing less than £100,000 or £150,000 would be of use to the Company, considering its future prospects.

The amendment was carried by a large majority on a show of hands.

Mr. INSKIP said that there were some gentlemen who were not entitled to vote, and the only thing to be done was to take a poll.

Mr. WHITE protested; but

The CHAIRMAN, after a brief consultation with other Directors, said he thought they must take a poll. They could not ignore the fact that a large number of shareholders had expressed their approval of the course the Directors had taken; and although a good many hands had been held up for the amendment that afternoon, they represented a comparatively small amount of capital.

Mr. INSKIP added that unless the matter were completed by August 1st the agreement would fall to the ground. If the suggestion of Mr. White was that the parties should meet and talk the matter over, he should advise the Directors to afford sufficient time for anyone who wished to discuss the question with a view to arriving at an amicable understanding; but if, as he understood it, the suggestion was that whenever the question came on there was to be a fight in a court of law the sooner it came on the better.

Mr. WHITE said he had intended asking the Directors to receive a certain number of shareholders to discuss various questions during the period of adjournment.

The Directors consulted in private for a few minutes, and on their return,

Mr. INSKIP said it had been decided to take a poll at once upon the motion for adjournment.

Mr. WHITE said he should test the legality of that course, and he suggested that those who supported him should leave the meeting with him.

These gentlemen having withdrawn, a poll was taken, and the motion for adjournment was declared lost, 87,285 votes being recorded against it, Mr. INSKIP saying that the gentlemen who had withdrawn represented about 3,000 shares.

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A resolution was unanimously adopted for the winding-up of the Company voluntarily. Mr. T. A. Welton, of London, was appointed liquidator, and was authorised to carry the agreement into effect, to receive the shares agreed to be allotted, with the cash payable thereunder, and to distribute the same among the members of the Company.

A vote of thanks to the Chairman for presiding concluded the proceedings.

West Coast of America Telegraph Company (Limited).

The following report has been issued by the Directors of this Company, and will be presented to the shareholders at the meeting to be held at Winchester House, E.C., on Monday, the 27th inst., at one o'clock :—

The gross income of the Company for the year ending December 31, 1891, as shown in the balance-sheet and revenue account, was £35 624 16s. 5d., against £65,323. 15s. 4d. for the year ending December 31, 1890. Adding £2,195. 12s. 11d. brought forward from the previous year makes a total of £37,820. 9s. 4d., and deducting from this the debenture interest and all other charges, there remains the sum of £1,413. 9s. 9d. to be carried forward.

During the revolution in Chili, four sections of the Company's cables, extending from Mollendo to Caldera, were cut by the Chilian war vessels ; these cables were repaired after about two months' interruption. The southern section, Valparaiso to Serena, was closed for public traffic by order of the Government for nearly six months, and it was not until September 1st last that communication was completely restored over the Company's system.

The negotiations mentioned in the last report have been brought to a satisfactory termination, and a land line is already in course of construction between Buenos Ayres and Valparaiso, which will connect the Company's system with those of the Western and Brazilian, the Brazilian Submarine, and the Eastern Telegraph Companies, and thus meet the competition of the Central and South American Telegraph Company.

The Directors extremely regret the death, on February 19th last, of their late esteemed Chairman, Mr. Alfred Marshall, by whom the above negotiations had, up to that date, been chiefly conducted on behalf of the Company. Sir John Pender, K.C.M.G., who has taken an active part in bringing about the arrangement above alluded to, will, it is understood, continue to give it his valuable support as Chairman of the new connecting Company. Mr. J. Denison Pender, a Director of the Brazilian Submarine and other telegraph companies, has kindly consented to join the Board, and to occupy the chair of this Company, and will accordingly be proposed for election at the general meeting of the shareholders now called. This accession of strength and the amicable working arrangements with the Brazilian Companies open up a fair prospect for the future of the West Coast Company.

Mr. Henry Roberts and Mr. Frederick Walters are the Directors retiring by rotation ; both are eligible, and offer themselves for re-election. The auditor, Mr. J. Weise, of the firm of Messrs. Turquand, Youngs, Weise, Bishop, and Clarke, retires ; but, in consequence of the uncertainty of his health, does not seek re-election. Mr. John Francis Clarke, however, a member of the same firm, offers himself to the shareholders for election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

ELECTRICAL COAL-CUTTING CONTRACT CORPORATION (LIMITED).—This Company was registered on the 18th inst. with a capital of £402,000, divided into 60,000 ordinary shares of £5 each, 20,000 deferred shares of £5 each, and 2,000 founders' shares of £1 each. The objects are to enter into and carry into effect an agreement, which has already been prepared, and is expressed to be made between the Woodfield Syndicate (Limited) of the one part and the Corporation of the other part ; to acquire, develop, grant licences in respect of or otherwise turn to account the patents, patent rights, and privileges referred to in the said agreement ; to carry on in the United Kingdom all or any of the trades or businesses of colliery proprietors, coke manufacturers, coal cutters, contractors, electricians, electrical contractors, electrical and mechanical engineers, suppliers of electricity for the purposes of light, heat, sound, power, or otherwise ; and of manufacturers, suppliers on the hire, hire purchase, or any other system, hirers and dealers of and in all machinery, apparatus, plant, materials, and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The signatories are :—Sir Archibald C. Campbell, Bart., M.P., Blythswood, Renfrew ; Lindsay Wood, The Hermitage, Chester-le-Street, Durham ; the Hon. George W. Winn, Nostell Priory, Wakefield, Yorkshire, colliery manager ; James R. Knowles, Westwood, Ince, near Wigan, Lancashire, mining engineer ; Septimus Rivington, Kilmeny, Wimbledon, Surrey, publisher ; Walter T. Goolden, 28, Westbourne Park, electrical engineer ; and Frank Stobart, J.P., Biddick Hall, Fence Houses, Durham.

EXPANDED METAL COMPANY (LIMITED).—This Company has been registered with a capital of £125,000, in £1 shares. Object : To acquire as a going concern the business of working certain patents and inventions relating to improvements in metal trellis or lattice work, now carried on by the British Metal Expansion Company (Limited) at West Hartlepool.

LONDON AND SUBURBAN MESSENGER AND GENERAL AGENCY COMPANY (LIMITED).—This Company was registered on the 18th inst., with a capital of £25,000, in £1 shares, to establish and carry on the business of general messengers, carriers, and agents (either in connection with the electric call system and the telephone system or one of them or not).

WILLIAM HARVIE AND CO. (LIMITED).—This Company has recently been registered in Scotland, with a capital of £30,000, in 8,000 preference and 22,000 ordinary shares of £1 each, the object being to acquire and carry on the business of William Harvie and Co., lampmakers, brassfounders, electrical engineers, &c.

ELECTRICAL STANDARDISING, TESTING, AND TRAINING INSTITUTION (LIMITED).—The annual return of this Company, made up to December 31, 1891 (no ordinary general meeting having been held in 1891), was filed on the 10th inst. The nominal capital is £10,000, divided into 1,900 ordinary and 100 founders' shares of £5 each. Seven shares have been taken up, but no calls have as yet been made ; the original signatories being the only shareholders.

LATIMER CLARK, MUIRHEAD AND COMPANY (LIMITED). — The annual return of this Company, made up to May 12th, was filed on the 19th. The Company was registered on October 22, 1883, with a capital of £100,000, in £10 shares. At the time of making up 4,709 shares had been taken up, and upon each of these the full amount had been called and paid.

CITY NOTES, &c.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons on this Company's Four per Cent. Mortgage Debentures to bearer due on July 1st next, will be paid on and after that date at the Alliance Bank, Bartholomew-lane, London, E.C. Coupons must be left at the Bank three clear days for examination. Warrants in payment of the interest on the registered debentures will be sent out on June 30th. The Debenture Register will be closed from Monday, the 27th, to Thursday the 30th inst., both days inclusive.

ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED).—Coupons No. 9 of the First Mortgage and No. 4 of the Second Mortgage Debentures will be paid, less income-tax, by the Alliance Bank, Bartholomew-lane, on and after the 1st prox.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons on this Company's second issue of Five per Cent. Debentures, due 30th inst., will be paid on and after that date at the Alliance Bank, Bartholomew-lane, London, E.C. Coupons must be left at the bank three clear days for examination.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 19th were £771, as against £721 for the corresponding period of last year, being an increase of £50. The total receipts to date, from January 1st last, amount to £19,707, against £18,500 in the corresponding period of 1891, being an increase of £1,207.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupons due July 1st next on their Five per Cent. Mortgage Debentures will be paid on and after that date at the banking house of Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

INDO-EUROPEAN TELEGRAPH COMPANY.—This Company's branch station at East India-avenue, E.C., has been removed to 6 and 8, Lime-street Square, E.C., where it is connected by special wire with the Company's chief offices at 18, Old Broad-street, London, E.C. The branch office is open from 10 a.m. to 7 p.m., closing on Saturday at 3 p.m.

MADRID TELEPHONE COMPANY.—The revenue of this Company last year was £22,381. Of this sum £7,161 was net profit.

NATIONAL TELEPHONE COMPANY (LIMITED).—This Company have resolved, subject to final audit, to recommend the following dividends for the last half year, namely, at the rate of 6 per cent. per annum, less income tax, on the amounts paid up on the first and second preference shares, and at the rate of 7 per cent. per annum, less income tax, on the amount paid up on the ordinary shares, making, with the interim dividend already paid, 6 per cent. for the year ending April 30, 1892. The transfer books of the Company will be closed from July 1st to July 14th, both days inclusive, and the dividend warrants will be posted on the latter date.

ST. JAMES AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED). A private meeting of the founders' shareholders in this Company was held on Wednesday last at Winchester house, Old Broad-street, E.C., to which reporters were not invited. With reference to the circular issued to the founders' shareholders, and signed by Messrs. Fry, Sturdy, Kitchin and Francis, the Directors of the Company state that the proposed meeting was called without consultation with them, and that the statements in the circular were *ex parte*, and must be taken as such.

TELEPHONE COMPANY OF AUSTRIA (LIMITED).—Coupons No. 15 of the Five per Cent. Debentures will be paid, less income-tax, at Martin's Bank, 68, Lombard-street, E.C., on and after the 1st prox.

WEST AFRICAN TELEGRAPH COMPANY (LIMITED).—A balance dividend of 5s. per share is proposed by the Directors, making a total payment of 4 per cent. for the year ended December last.

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WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The coupons due June 20th on the debentures of this Company will be paid by Messrs. Barclay and Co., Lombard-street. Coupons should be left three clear days for examination.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the fortnight ended June 15, 1892, amounted to £2,621, as compared with £2,538 in the corresponding period of last year, an increase of £33.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 17, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,578.

CRICKET.—JOHNSON AND PHILLIPS C.C. *v.* CITY ELECTRIC C.C. (MESSRS. H. F. JOEL AND CO.)—This match was played on Saturday, the 18th inst., on Victoria Field, Charlton, and resulted in favour of Johnson and Phillips C. C. by 5 wickets and 26 runs. Score :—

CITY ELECTRIC C.C.—F. Joel c and b Jepson, 0 ; Goater b Reed, 0 ; W. Smith b Jepson, 15 ; Hiscock b Jepson, 9 ; Pearson b Jepson, 0 ; Youngman c Broome b Jepson, 0 ; Lowe b Reed, 4 ; Aubert b Reed, 2 ; Smith b Jepson, 0 ; Reuham b Jepson, 0 ; Barrera not out, 0 ; extras 8—Total, 38.

JOHNSON AND PHILLIPS C.C.—Jepson c Smith b Joel, 1 ; Zambra c Joel, 0 ; Craston b Smith, 11 ; Short b Joel, 1 ; Broome, not out, 39 ; Williams b Smith, 1 ; Reed not out, 4 ; Phillips, Sennett, Wall, and Riley did not bat ; extras 7—Total for 5 wickets, 64.

COMPANIES' SHARE LIST.

PRESENT AMOUNT	AMOUNT OF SHARE.	LAST DIVIDEND.	NAME.	PREVIOUS WEEK'S PRICE, JUNE 15.	PRICE WEDNESDAY, JUNE 22.	RATE PER CENT. YIELDED.	DIVIDEND DUE.	BUSINESS DONE DURING WEEK ENDING JUNE 22. Highest.	Lowest.
			TELEGRAPHS			£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	48 49	48 49	5 12 3	Jan., Apr., July, Oct.	48	
£2,849,510	Stock	25/0	Do. Preferred	88 89	87½ 88½	5 18 8	" "	88½	87½
£2,849,510	Stock	5/0	Do. Deferred	10¾ 11¼	10¾ 11¼	.. ..	" "	11⅛	10⅝
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101 104	101 104	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½ 10¾	10½ 10¾	7 8 10	Mar., June, Oct., Dec.	10⅝	10⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	105 109	105 109	4 11 9	June and December	..	..
$7,716,000	$100	$13¾	Commercial Cable Capital Stock xd	155 160	155 160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3¾	3½ 3¾	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½ 11¾	11½ 11¾	5 19 2	Jan., Apr., July, Oct.	11½	11½
400,000	10	2/6	Eastern	14⅜ 15	14⅜ 15	4 6 8	" "	14⅜	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	15½ 15⅝	3 16 2	" "	15¼	14⅞
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 11 9	February & August	..	..
250,000	10	6/6	Eastern Extension	15 15½	15 15½	4 11 10	Jan., Apr., July, Oct.	15 7/16	15 5/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	102 105	3 16 2	February & August	..	..
180,227	10	2/6	Globe Telegraph and Trust	10½ 10¾	10½ 10⅝	5 1 2	Jan., Apr., July, Oct.	10⅝	10 7/16
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	15½ 15⅝	3 18 1	" "	15½	..
150,000	10	7/2	Great Northern	18⅞ 19¼	18⅞ 19¼	4 9 2	Jan., April, and July	19⅛	18¾
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	40 42	40 42	5 19 1	May and November	41½	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	8/0	Reuter's xd	6½ 7½	6½ 7½	5 6 5	April and October..	..	..
3,381	£100 Cert.	£1½	Submarine Cables Trust 6%	116 120	115 120	5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	2½ 4½	3½ 4½	5 11 1	January and July ..	3⅞	..
£150,000	100	8%	Do. Debentures 8% 1902	104 108	104 108	7 8 2	June and December	..	..
88,321	10	6d.	West India and Panama	1½ 1⅝	1½ 1⅝	.. ..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10¼	9½ 10	6 0 0	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	8⅞	..
67,007	15	6/0	Western and Brazilian	9¼ 9⅞	8⅞ 9¼	8 2 6	" "	9⅛	9
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 3	" "	6 5/16	6½
30,364	7½	4/6	Do. 5 per Cent. Deferred	3 3½	2⅞ 3¼	.. ..	" "	3⅜	2⅞
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105 108	105 108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105 108	105 108	5 11 1	" "	106⅛	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
£24,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance xd	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
£20,000	£1	4⅜d.	Oriental (11s. paid)	1 1 5/16	1 1 5/16	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛ 4⅜	4⅛ 5⅛	5 17 1	June and December	5 1/16	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13¼ 13½	13¼ 13½	4 7 3	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12⅛ 13	12⅛ 13	4 12 4	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	108 110	109 111	4 1 1	January and July ..	110	109
58,000	5	1/0	United River Plate	1½ 2⅛	1½ 2⅛	.. ..	" "	1⅝	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£8 paid)	9⅜ 10¼	10 10½	..	..	10½	10⅜
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	.. ..	2½ 3½	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5⅛	5⅝ 6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 6	5½ 6	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 7/16	3 7/16 3 7/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	⅜ 1⅛	⅜ 1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	7¼ 7⅝	6¾ 7¼	..	..	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5	4 5	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8½ 9	8½ 8¾	..	..	..	..
7,900	£5	7%	Do. 7% Preference	8 8¼	7⅞ 8¼	..	..	..	..
42,853	5	..	Westminster Electric Supply (fully paid)	6¼ 6⅜	6¼ 6⅜	..	..	6⅜	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/9	Brush Electrical Engineering	2⅞ 3⅛	2⅞ 3⅛	..	..	3 1/16	2⅞
69,996	2	6%	Do. 6 per Cent. Preference	2 2⅛	2 2⅛	5 2 7	..	2	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5⅞	5⅝ 6	5 16 8	January and July ..	5⅝	..
17,139	5	17%	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	12/0	Electric Construction	5⅝ 6	5½ 5⅞	..	..	5⅞	5⅝
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅝	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½ 20½	19½ 20½	6 1 11	February & August	20⅝	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3½ 4½	.. ..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛ ⅜	⅛ 5/16	.. ..	..	..	..
78,949	5	2/9⅝	Swan United (£3. 10s. paid)	3½ 4	3½ 3¾	10 5 6	May and November	3 1/16	3⅜
36,250	12	36/0	Telegraph Construction and Maintenance	44 46	44 46	5 4 9	March and July....	46	45
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	.. ..	⅛ ⅜	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	.. ..	2½ 3	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
50,000	£10	—	City and South London Railway	2½ 3½	2½ 3½	—	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

The correspondence between the St. James' and Pall Mall Company and the Board of Trade, which we publish *in extenso* elsewhere in the present issue, shows that at any rate the particular case of gas-meter damage in question was not due to any defect of the St. James' mains. It is natural, and, perhaps, even desirable, that the gas journals should be for ever on the alert to criticise the proceedings of electric lighting companies; but if electrical journals were to devote a proportionate amount of space to the chronicling of small beer in the shape of gas accidents, they would have but little room for anything else.

Negative results in experimental science are rather unsatisfactory, because it is impossible to say whether a certain effect is really absent; or whether it fails to be visible, merely because the apparatus is not sufficiently sensitive to detect the effect if it really exists. The only conclusion that such experiments really permits is, that the effect, if any, is less than a certain magnitude. This is surely much less satisfactory than a measurement of its magnitude, however rough.

The earliest attempts to measure the velocity of light by means of dark lanterns flashed from neighbouring hill-tops could not possibly succeed, so crude was the mode of experiment. A negative result was the natural consequence. Had Roemer, who calculated the velocity of light in 1667 from apparent discrepancies in the times of the eclipses of Jupiter's satellites, arrived at a result three times too large or three times too small, instead of a result differing only by about one-third from the most accurate measurements, his result, though very inexact, would have been of immense importance. Nobody, probably, made a greater number of negative experiments than Faraday, a large proportion of them having been made with the expectation of a negative result. All these were of immense help to him as guides; but his real advances are based on his positive results.

After a number of negative results such as those which Dr. Oliver Lodge and others have made relating to the ether theory, a strong presumption may be arrived at, through the process of elimination, if they are all accordant; but it can hardly be called a certain conclusion. Dr. Oliver Lodge, in the letter which will be found in our correspondence columns, says that "an answer 'no,' though a negative reply, may be as decided and *positive* an answer as 'yes.'" But in experimental work can we ever induce nature to say "no"? She merely keeps silent, and forces us to put up with the unsatisfactory verdict of "not proven."

In *The Electrician* for November 20, 1891, Dr. Louis Duncan described a method by means of which a number of alternate-current curves could be obtained simultaneously with the aid of a single contact-maker. It consisted of passing a current from a battery of cells through the revolving contact apparatus and also through the primary coils of a series of dynamometers. The currents in the secondary coils of these instruments were caused by the voltages or currents which were being analysed. For every position of the contact-maker, corresponding with a definite instant of the period, the readings of the dynamometers were taken and plotted so as to obtain simultaneous curves of voltage or current. This method seemed admirably adapted to the purpose for which it was intended, although apparently requiring special dynamometers, and being subject to the defect that the contact apparatus had to be made capable of carrying an appreciable electrical current. In all methods of determining these curves hitherto used, the contact-maker has been used merely for completing a condenser circuit, or in such a way that practically no current passed at the instant of contact; and so much depends upon the certainty with which the contact piece performs its duty, that any disturbing element, such as the passage of a strong momentary current, should be avoided if possible.

Messrs. J. E. Moore and E. M. Tingley have, however, recently tried this method with promising results; and in the *Electrical World* of June 4 will be found some interesting alternate-current curves obtained by them. The dynamometers used were of the ordinary Siemens pattern, but the current across the contact piece was only a tenth of an ampere. The curves obtained are of the same general type as those obtained by other methods, and already published. For low magnetisations, the current curves differ very little in shape from the voltage curves; but for high magnetisation the current rises very slowly at first, then mounts quickly to its maximum value, and afterwards falls with great rapidity to zero again.

A well-established principle of patent law was explained by Lord Abinger when he said that because all mankind have

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been accustomed to eat soup with a spoon a man could not take out a patent for eating peas with a spoon; and similarly the method of testing transformers which has been devised by Dr. SUMPNER, and which is fully described by him in the present issue, is confessedly based upon Dr. J. HOPKINSON'S well-known method of testing dynamos, but is none the less important even if it is not novel in principle. It is indeed rather surprising that Dr. HOPKINSON himself, in carrying out the very elaborate test of a transformer which is described in another column, did not use this adaptation of his own method. We must repeat the confession, already made in this journal, that we are getting rather tired of transformer testing; but it still seems to have a wonderful fascination, and we have by no means heard the last of it. Transformers, their design and behaviour, have been revelled in from a mathematical point of view by many writers who seldom see or care to see an actual example. Absurd bundles of iron and copper have, on the other hand, been built by manufacturers who were innocent of any mathematical knowledge whatever.

THE development and perfecting of the alternate-current transformer seems likely to depend, not on its practical working, for it is impossible to tell whether a transformer is working in a creditable manner when it is simply engaged on the ordinary work of electric lighting, but on the art of testing. Those types which pass the tests best will take the first place, unless, indeed, cheapness of construction or economy of material are found to be of greater importance than those electrical losses which it is the object of testing to discover and to measure. Just as Dr. HOPKINSON coupled two nearly identical dynamos on one shaft and allowed them both to work at full load opposing each other on the same circuit, and supplied a small amount of power from an external source to make up for the losses, so Dr. SUMPNER proposes to arrange two transformers, and to supply, and thus to measure, by means of a small third transformer, the power lost in the large ones.

THE Paper read by Mr. WILLIAMS at the last meeting of the Physical Society forms a most important contribution to the theory of dimensions. Professor THOMPSON'S idea that a directional quantity must be represented by a unit which is itself of the nature of a vector, has been followed up with marked success. The old view, which many have more or less unconsciously held, that the dimensions of a physical quantity can be completely represented by reference to the fundamental units of length, mass, and time, seems entirely fallacious, and, indeed, the absurdity of it is sufficiently apparent when we find that the dimensions of most physical quantities are represented in terms of these units by a most extraordinary combination of powers. Professor RÜCKER'S former Paper on the suppressed dimensions of physical quantities seemed to indicate that it is doubtful whether the true dimensions of any quantity are really known.

CAN it be said, for instance, that we are sure of the nature of mechanical force? This is a quantity which, like an electric current, can only be detected by the effects it produces. There is no such thing as a theoretical proof of the law known as the parallelogram of forces. Any so-called proof which can be given is either purely experimental, or depends upon definitions and assumptions which are the result of experiment. If it be assumed that the force acting on a body is measured by the product of its acceleration and its mass, the parallelogram of forces can be proved. But no real proof can be given that the dimensions of a force are those of mass multiplied by acceleration. We cannot, for instance, be sure that the gravitational force between two material bodies depends only on the masses of these bodies and their distance apart; and, as a matter of fact, we know that with electric and magnetic attractions we have to take into account the nature of the medium between the bodies. In determining the dimensions of force we may, in fact, have suppressed some quantity analogous with κ and μ in the electro-magnetic system, and a recognition of which may possibly, in the end, effect a simplification of ideas.

SURELY, if slowly, the views which Mr. OLIVER HEAVISIDE has developed in the pages of *The Electrician* are leavening the scientific world. The latest evidence is to be found in this elaborate Paper of Mr. WILLIAMS. We venture to characterise the Paper as the most important that has been produced before the Physical Society during the current session; not because it announces any new discovery, but because it virtually applies a new weapon for attacking some of the knotty problems of ultimate physics. There is nothing inherently new in the discrimination of physical quantities into vectors and scalars, the former having the property of direction as well as magnitude. But the introduction of vector ideas into the expressions for the "dimensions" of physical quantities has, in Mr. WILLIAMS' hands, certainly thrown some light on the obscure nature of those "suppressed dimensions." Whether the sacred symbol 4π is henceforth to disappear from electrical formulæ by the adoption of OLIVER HEAVISIDE'S "rational" system of units, or whether it remains for a time, Mr. WILLIAMS has done a useful service in pointing out precisely the physical and spatial relations which its presence in those formulæ implies. To the plain man the recurrence of this symbol is an abomination. He would certainly prefer in practice to relegate it to the realm of "suppressed dimensions."

WHEN Mr. TESLA showed a flame in which there was no consumption of material, but, as he put it, merely a transfer of energy, it appeared to be an intense form of the well-known brush discharge at a point, and, like the luminosity of a vacuum tube, seemed to come under the convenient term "electrical discharge," which commits us to nothing. A lightning flash, on the other hand, has been considered by some authorities to consist in the incandescence of the air through which the "discharge" takes place. No one, however, has seen red-hot air, and no one has attempted to explain at what point, if any, air becomes self-luminous. When, however, high-pressure discharges are forms of popular enter-

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tainment, we get familiarised with the long writhing ribbon-like flames that play between the terminals under several thousands of volts.

PROF. CROOKES has given one of those simple explanations of these flames which are surprising only in that they have not been thought of before. The flame is a true flame, and consists of nitrogen burning in air, that is, combining with the oxygen of the air, and forming nitric acid. Fortunately, the combination of oxygen with nitrogen does not take place with sufficient evolution of heat to maintain the combustion, or, as Prof. CROOKES suggests, the first lightning flash would have fired the air, and deluged the earth with a sea of nitric acid. To make all this nitric acid a good deal of the ocean would be needed, and even then a lot of nitrogen would be left over. We must be thankful that the molecules of oxygen and nitrogen get on so good-humouredly together, and that we escape by the skin of our teeth from this as from other tricks which Nature is within an ace of playing us.

NOWHERE have these long flames been seen to better advantage than at the demonstration of Messrs. SIEMENS BROS. at the Crystal Palace, or those of Messrs. SWINBURNE and Co., who, by-the-bye, have been compelled, in a rather arbitrary way, to stop their experiments, and who very properly declined to remove their stall and exhibit fully a fortnight before the close of the Exhibition, because the space which had been allotted to them was wanted for a concert.

The Westminster Electric Supply Corporation.—The Board of this Company have reduced the standard price of current supplied to 7d. per unit from to-day.

The Cable Companies.—In its last issue our financial contemporary, *The Statist*, had a well-written article drawing the attention of investors to submarine telegraph securities.

Old Students' Association.—On Thursday last week Mrs. Silvanus Thompson held a most successful and largely attended reception in connection with the Old Students' Association.

Brussels.—The tender of the India-Rubber, Gutta-Percha, and Telegraph Works Company, of Silvertown, for the electric lighting of Brussels, was definitely sanctioned on Monday by the Conseil Municipal.

The Varley Testimonial.—The meeting called for to-day at 4 p.m. will be held in No. 4 Room, Westminster Palace Hotel, instead of at the offices of the Institution of Electrical Engineers, as previously announced.

The Spanish Telegraphists' Strike.—The strike of Spanish telegraph operators was settled on Friday last, as a result of the mediation of the Minister of the Colonies. Telegraphic communication is now restored.

Personal.—Prof. George Forbes has returned from the United States, and has been appointed consulting electrical engineer to the Cataract Construction Company, who are undertaking the utilisation of the water-power of the Niagara Falls.

Dundee.—At a recent meeting of the Dundee Gas Commissioners it was resolved to borrow, subject to the approval of the Secretary for Scotland, a sum of £20,000, for the purpose of erecting and equipping the proposed electric lighting works.

High-Speed Electric Traction.—M. Van den Kerchove, of Ghent, is in negotiation with the Belgian Government for permission to lay down an electric rapid transit line between Brussels and Antwerp. M. Van den Kerchove proposes a ten minutes' service, and to do the trip of 27 miles in 25 minutes.

The Institution of Electrical Engineers' Conversazione.—We are requested to state that owing to the limited cloak-room accommodation at the Royal Institute of Painters in Water Colours, it would be well if soft hats or opera hats (rather than ordinary tall hats) were worn in coming to the Conversazione this evening.

Proposed Electrical Exhibition in Milan.—A meeting has been recently held at Milan, says *Industries*, by the principal engineers and manufacturers to consider whether it would be advisable to hold an Electrical Exhibition in that city; and it was decided to hold one in 1894. A commission of five members was appointed to draw up the necessary programme.

City and Guilds of London Institute.—The entrance examination for the Central Institution will be held on September 19-22nd, and for the day department of the Finsbury Technical College on September 27th. The new session of the Central Institution commences on September 28th, and that of the Finsbury Technical College on October 4th. For further particulars see our advertisement columns.

"The Electrician" Annual Dinner.—The annual dinner of gentlemen associated with *The Electrician* was held at the Criterion Restaurant, on Monday last, under the chairmanship of Sir James Anderson. The party numbered over 50, and amongst the visitors were Sir Eyre M. Shaw, Sir Albert Cappel, M. Despecher, Mr. G. Ward, Dr. J. A. Fleming, Prof. J. A. Ewing, Capt. Davies, Mr. W. O. Smith, and other gentlemen well known in the electrical profession.

New South Wales and the Chicago Exhibition.—The colony of New South Wales is said to be dissatisfied with the arrangements made for the exhibition of its mineral and other products at the Chicago Exhibition. It is declared on behalf of the Colonial Government that as the original conditions have been ignored by the Executive at Chicago, the colony will, unless arrangements are made by which the products can be exhibited in one court, withdraw from the Exhibition altogether.

Accumulator Efficiency.—M. Vitte has sent the following figures to *L'Industrie Electrique* with regard to the mean monthly efficiency of a battery of Tudor cells installed at the electrical works of the Lyons Gas Company. From March 5 to March 31 last 2,828 kilowatt-hours were put into the battery and 2,477 were taken out, which means an efficiency of 87·5 per cent. The battery in question has a capacity of 150 kilowatt-hours, and its average daily output is about two-thirds of this.

Obituary.—We regret to record the death, at his house in London, on the 26th ult., at the age of 50, of Mr. William Payton, Secretary of the Globe Telegraph and Trust and West African Telegraph Companies. Sir John Pender, as well as the other Directors of the Cable Companies, had a high appreciation of the deceased gentleman's abilities, and reposed great confidence in him both in his official and private capacities; while his generous and kindly disposition endeared him to the large number of friends in all parts of the world, by whom his loss will be deeply regretted.

"Total Light."—The *Journal of Gas Lighting* comments on the "animated little controversy" which has been going on in *Industries* on the subject of "candle-feet," and the "curious result that a candle gives a total light of 4π, or $12\frac{1}{2}$ candles." "It will be a mercy," says our contemporary, "if the electricians do not get hold of this pleasing mathematical convention, and hoodwink unsuspecting local authorities with it One can, indeed, hardly contemplate with equanimity the result of bringing such a magnificent specimen of the 'unearned (mathematical) increment' within arm's length of the Brush Company."

The Belt Line Tunnel.—While the minor details of the Belt Line tunnel at Baltimore have not been decided upon, says the *Electrical World*, the essential features of the installation are now known. The 80-ton locomotives will be capable of developing 1,200 H.P. each. There will be four driving axles, on each of which will be keyed the armature of a 300 H.P. motor. The conductors will be either a third rail of iron or some sort of a large copper tube laid above the ties and thoroughly insulated. The potential is to be 500 volts. The power station will probably have a capacity of 3,000 H.P. There will be four compound Corliss engines of about

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750 H.P., each belted to or directly coupled to the generators, no counter shaft being employed.

Electricity in Mining.—The electric plant at the Virginius mine is an illustration of the great benefits to Western mining interests which have been brought about by some applications of electricity as a motive power for mining machinery. An American paper says:—"The Virginius is situated on Mount Aniffles, near Ouray, Colo., at an altitude of some 12,500ft. It formerly cost $15 per ton for coal with which to operate this mine, as all fuel had to be transported up the mountain on burros. The cost of coal reached $100 per day, or an annual aggregate expense of $36,000 for fuel alone. Every cent of this heavy running expense is now saved to the mine-owners. The new operating force of the Virginius is water-power, transmitted by dynamos located at Red Canyon Creek, four miles from the mine."

Central Station Lightning Arresters.—The precautions which American central-station engineers find it necessary to take against lightning is one of those little things which remind us of the different conditions under which central-station work is carried out in England and in the States. Thus, at Springfield, Ill., the lightning arresters which were formerly placed in the top of the tower from which the circuits were distributed have recently, says the *Electrical Engineer* of New York, been changed and lowered in the tower to a level with the ceiling of the dynamo-room, and pipes are run so that in case of an arc from lightning they can be surrounded with live steam. This precaution was taken from experience gained from a recent storm, when an arc formed by the coming in of the lightning upon the arresters almost resulted in a disastrous fire.

Berlin.—The Berliner Electricitätswerke intend from the 1st January next to make several concessions to their customers, the most important of which is that consumers will be allowed to supply their own lamps. Consumers who undertake the supply and care of the lamps themselves will then pay for each arc lamp a yearly sum of 15 marks, instead of 30 marks as formerly, and for each incandescent lamp two marks, instead of five marks as formerly. The calculation of the price for electricity consumed will be based, as hitherto, on the rate of 3·6 pfennigs per lamp hour. Furthermore, consumers will be permitted to run electric power plants and accumulators of all kinds from the Company's mains, so long as the same meet the rules and regulations prescribed by the Company in this regard.

Electrical Bills in Parliament.—The Royal assent has been given to the following electrical Bills:—Telegraphs, Electric Lighting Orders Confirmation (No. 5), Central London Railway, and Great Northern and City Railway. The following Bills are suspended:—Baker-street and Waterloo Railway (waiting for third reading in the Second House), Blackpool Improvement (read the second time in the First House), City and South London Railway (Islington extension) (read the second time in the First House), Hampstead, St. Pancras, and Charing Cross Railway (read the second time in the First House), London County Council (Subways) Bill (waiting for report from the Select Committee in the Second House), National Telephone Company's Bill (read the first time after introduction), Waterloo and City Railway (read the second time in the First House).

Bradford Tramways.—Our readers will be glad to hear that the experiment undertaken by Messrs. Easton and Anderson in conjunction with Mr. M. Holroyd Smith, on behalf of the Bradford Corporation, to demonstrate the efficiency of electric energy in propelling tramcars up steep hills, have been brought to a successful conclusion, and arrangements are now being made for the construction and equipment of two miles of line where the average rise in the total length is 1 in 24, the road in many places being as steep as 1 in 13·3. The Corporation has consented to allow the temporary overhead conductors used for the demonstration to remain in position for another fortnight in order that gentlemen from other towns interested in tramways may witness the running of the cars. Should any of our readers desire to personally inspect the tramway and its working they may, on application to the London office of Messrs. Easton and Anderson (Limited), 3, Whitehall-place, S.W., be furnished with the necessary permits.

The Severe Thunderstorms.—The violent thunderstorm which occurred in the Metropolis on Tuesday and Wednesday last was also felt very severely over the midland, southern, and eastern portions of England. Amongst the many accidents caused by lightning was that at a house in Lordship-road, Stoke Newington, which was set on fire. Considerable damage was done at Richmond; and amongst other places more or less injured by lightning was Moor Hall, in Essex, a farmhouse at West Grinstead, a technical school at Bickley, a house at Brasted (Kent); whilst animals suffered somewhat severely from lightning at Luton, St. Alban's, Hatfield, Saffron Walden (Essex), and Harefield. A correspondent, Mr. W. B. Clarke, writes to us under the date of June 28th, as follows:—"No doubt the storm of to-night has been the subject of numerous communications to you, but I thought I would mention one flash in particular which occurred just before nine o'clock. This was a flash from sky to earth of zig-zag path, which left a stream of sparks in its train. This was very noticeable, and was seen by several. I cannot call to mind having before seen such a noticeable stream of sparks following a flash."

Electric Railways of the Future.—Mr. Westinghouse, says *Industries*, is reported to have given it as his opinion that the ordinary locomotive will never be replaced by its electric rival. There is, however, a growing idea that the ordinary railway will soon be run from stationary power stations. Electric underground railways will, of course, come into use, as they avoid the ventilation difficulty, which gives them an advantage at once; but in ordinary railway working the smoke and steam from the engine are of little importance. It is generally taken for granted that electric railways will have a much higher efficiency. It must be remenbered, however, that the locomotive is one of the best examples of modern engineering, and that, in spite of the difficulties of the case, it is a very efficient steam engine. The advantage of the stationary engine over the locomotive can hardly be great enough to allow a margin for the losses by conversion of mechanical into electrical power, by transmission, and by reconversion back to mechanical power. The electrical difficulties are also serious. The somewhat barbarous practice of wasting most of the available pressure on resistances at starting will, of course, be abandoned before long, but even then there seems little reason for thinking that the steam locomotive is doomed. The ideas of making electrical automatic block systems are too far-fetched to be of much importance. A tenth of the expense involved would make the present railway systems automatically safe—that is, unless something went wrong with the automatic gear.

The Proposed Electric Lighting of the Thames Embankment.—At the last meeting of the London County Council, the Highways Committee reported that their attention had been directed to the defective lighting of the Victoria Embankment. With regard to a supply of electrical energy, three courses appeared to be open for adoption—viz. (*a*) to obtain the supply from a company; (*b*) for the Council to lay the mains and provide and fix the lamps and then to obtain the supply from a company; and (*c*) for the Council to light the Embankment by means of an independent installation. The third course appeared to be the proper one for the Council to take. The Committee proposed that lamps of from 1,000 to 1,200 c.p. should be placed in the centre of the road, at about 50 yards from each other. About 50 of these lamps would be required for the carriage-way. The generating plant might conveniently be placed upon the land belonging to the Council under the Charing-cross railway bridge. The capital expenditure, if the above arrangement were adopted, would probably not exceed £10,000; while the cost of maintenance, including depreciation, repair, and interest on capital, and also providing amply for labour, would probably not exceed £2,000 per annum. After some discussion, the recommendation of the Committee was agreed to, with the following addition:—"And that the Highways Committee do also confer with the Bridges Committee and the Parks Committee respectively, and report whether the plant can be established on a sufficient scale to enable Westminster and Waterloo bridges and the Embankment gardens to be lighted from the same source."

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NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 165.*)

13. Joint in Core.—Before the work of jointing and splicing is commenced the end on the new piece of cable to be joined on is brought up into position for paying out, so that everything will be ready to pay out as soon as the splice is completed. It is not usual to fit repairing vessels with a separate brake gear aft for paying out as in the large cable-laying steamers, the spare drum and brake on the picking-up gear being available for this purpose. As these are also under steam control when required they further constitute a duplicate set of gear for grappling or picking up; but for paying out the drum is thrown out of gear with the engine, and controlled entirely by the brake.

In the tank from which cable is to be payed out, the end is passed up through the crinoline, and out through the eye above the tank, thence forward to the jockey pulley and drum, round which it is wound four or five times. If it is intended to pay out from the bows the end is taken further forward into position under dynamometer pulley, and then doubled back for splicing; but if paying out is to be done over the stern, the end is taken aft, passed under pulley of dynamometer at that end of ship, over stern sheave, round outside ship to bows, and back inboard again over one of bow sheaves, where joint and splice are made. Arranged in this manner the cable will at once

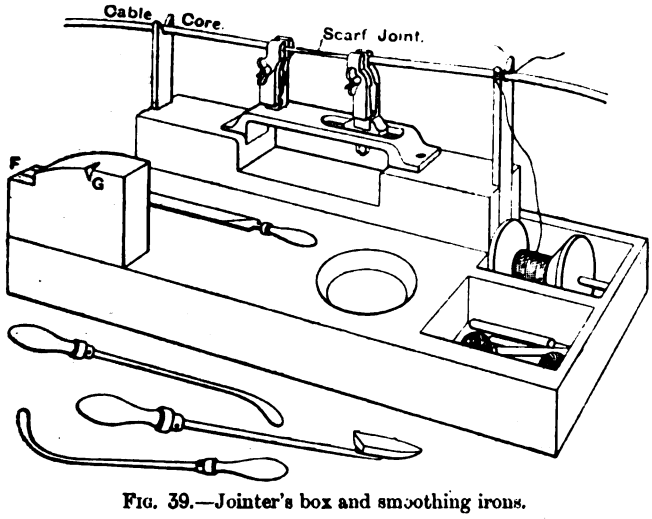

FIG. 39.—Jointer's box and smoothing irons.

take its proper place for paying out over the stern as soon as the finished splice is dropped overboard from the bows. It is now, however, the general practice in repairing work to pay out over the bows, this being most convenient for the short lengths of cable dealt with.

The cable having been got into position, the two ends are brought up together for jointing. On one end, which we will call the left end for distinction, the sheathing wires are unlaid for a length of about 90ft., exposing the same length of core. About 30ft. of core is then cut away, and the remaining end prepared for jointing. On the other end—the right end—the sheathing wires are unlaid for about 75ft., and 60ft. of core cut away, the remaining end being likewise prepared for jointing. To prepare for jointing the insulation is stripped off the end with a sharp knife to a distance of 3½in. or 4in., care being taken not to nick the wires with the knife. The strand is then opened out, each of the seven wires being scraped and cleaned bright with emery cloth, and then with a pair of pliers the whole twisted back again into a strand as before. The ends are then filed down taper on one side, as shown in Fig. 41, for a scarf joint, so that the ends when laid together exactly fit, and make no increase in the size of the conductor. On the jointer's box, illustrated in Fig. 39, there is a block of wood on the left side, in which is cut a niche G. This niche answers the purpose of a gauge to assist in filing both ends equally to the same taper. The end is laid in the niche and filed away till flush with the block, making the tapered part about an inch in length.

The jointer's box is also fitted with two upright hand vices or clamps, as shown, in which the ends are held together while jointing. But before clamping the ends thus, they are separately soldered over. For this purpose the soldering bit, spirit lamp and hood, shown in Fig. 40, are used. With a hood of this kind over the lamp a good draught of air passes through the small holes and out at the top, while the flame itself cannot be blown about by the wind. The soldering bit is also held over the hottest part of the flame, in a hole cut in the hood for the purpose. Either powdered resin or Baker's fluid is used as

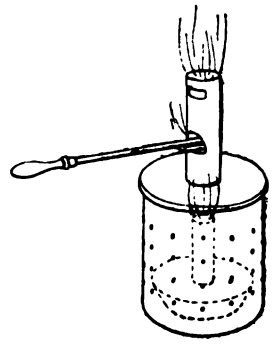

FIG. 40.—Soldering iron, lamp, and hood.

a flux. Sometimes the wire is soldered first, before filing the taper end. The ends being soldered, they are next laid in turn on the side of the block at F, and the rough corners left by the solder filed off; after which they are surfaced over with emery cloth. At this stage the ends are solid, fitting truly together, and presenting a bright silvery appearance. They are now held together in the clamps on the jointer's box, which grip the conductors close to where the insulation is cut away. One of these clamps is movable along a slot, so that when the wires are properly held they can be brought close together with a little pressure, by moving up this clamp as required, and then fixing it by screwing up the nut underneath. The joint is now bound round with fine copper binding wire. A length of this wire is unwound from the reel in the jointer's box, rubbed over with emery cloth, and then doubled in three or four like a flat band composed of three or four wires. So held, it is bound tightly round the joint in one direction, say from left to right, and to within a quarter of an inch of the clamps on each side. The whole is

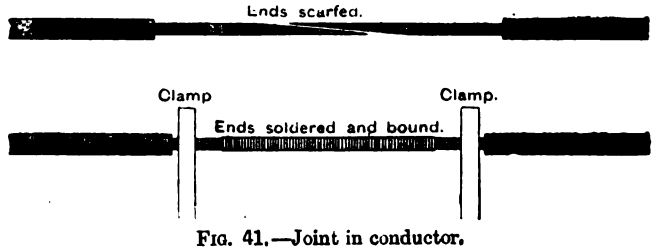

FIG. 41.—Joint in conductor.

then soldered over, the solder running in between the binding wires, and making a neat solid joint. Next, a second wrapping of binding wire is laid on, this time in the opposite direction—right to left—and close up to the clamps on each side. This wrapping is soldered only at the extreme ends for about a quarter of an inch from the clamps, the object being that in case the cable is subsequently fractured at the joint the wire not being soldered will not break with the cable, but open out and maintain continuity. Finally, the ends of the binding wire are snipped off, and a six-inch smooth file run over the soldered parts to take off any projecting points and make the joint perfectly regular all the way along.

So far there will not be found much difficulty in jointing after a little practice in keeping a nice clean tinned end on the bit. There is considerably more practice required in the succeeding operation of making the joint in the insulation, the difficulty being at first to keep all air bubbles excluded from the material while hot, and to finish with the jointed conductor

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perfectly central in its insulating covering. Should there be any air bubbles imprisoned in the joint they are sure to be the cause of ruptures in the insulation sooner or later in consequence of the great pressure at the bottom of the sea. This pressure amounts to one ton and a quarter per square inch for every 1,000 fathoms depth; and when the cable is sunk and subject to this pressure any places where air is imprisoned are burst open and cause serious faults.

The soldering fluid is first cleaned off the joint by rubbing with a clean bit of rag soaked in wood naphtha, and after drying it the first coat of Chatterton's compound is laid on. One end of a stick of this compound is heated in the spirit lamp flame, care being taken not to keep it in the flame long enough to burn, or there will be trouble from air-holes. The bare part of the joint is also heated very slightly to receive the coat. The stick of compound is then worked along over the joint as well as possible to cover every part, and is followed up by a smoothing iron. This is a smooth iron tool, curved at the end (Fig. 39), which, when heated and worked over the coating of compound, spreads it out in any desired way; thus where the compound is too heavily laid on in places it can be worked down into cavities so as to make it everywhere of the same depth. Any imprisoned air is worked out by this tool, and the coating finally smoothed round evenly by the finger and thumb, first wetted, so as not to adhere to the material. The gutta-percha covering of the core on each side of the joint is now dealt with, the spirit flame being held underneath while the core is turned round backwards and forwards. The ends are then drawn together till they are about ½in. apart, and one end is drawn down to a point, while the other is drawn over it (Fig 41 A), thus completely enveloping the joint in the same material as

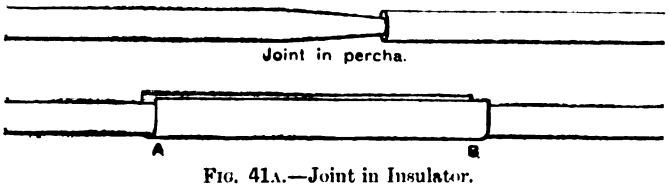

FIG. 41A.—Joint in Insulator.

the conductors on each side. The end so left is further heated and smoothed down. A second layer of compound is now spread over the percha, precisely as before. Some sheet gutta-percha is now taken, and a square piece about 8in. wide cut off. This is heated over the flame, and a strip cut off about 1½in. wide, which is then taken, and one end laid against the core underneath at A (Fig. 41 A), the other end hanging down. From this point the strip is pressed upwards against the core by the fingers working along from A to B, and is then heated again and pressed all round the core till the ends meet at the top, as in the figure. The reason for this careful procedure is to make sure there are no air bubbles imprisoned by commencing at one end and squeezing the strip against the core in every part till the whole is covered. When completely pressed all round, the two sides of the strip stick up close together, and are nipped together by the finger and thumb all along, so as to form a seam. The seam is then cropped close to the core with a pair of scissors, and the ends, which now butt, squeezed together. This coat is followed by a similar one put on in the same way, but with the full part of the strip over the seam of the last. The joint is then completed by working down smooth the ends of these strips at A and B, so as to taper off gradually on to the core on either side. A well-made joint is, when finished, from 6in. to 9in. long, and not much larger in diameter than the adjacent core. The beginner should experiment on short lengths of core, and test his joint by comparing its insulation with a few feet of perfect core by Clark's accumulation method. Then, if sound electrically, he should slice off half of the insulating covering with a sharp knife, so as to lay the joint bare along one side, and notice how near he has got the joint in the centre of the insulating covering. To get the joint central a good deal depends upon working the hands evenly over every part of the coatings as they are put on.

Before anything more can be done the joint must be thoroughly cooled, and for this purpose it is held down in a gutta-percha tray (Fig. 42) containing either a diluted mixture of muriate of ammonia and saltpetre, or a few lumps of ice in water. The proportions of this cooling mixture are given in Munro and Jamieson's "Pocket Book of Electrical Rules and Tables" as five parts of muriate of ammonia to five parts of saltpetre and 16 parts of water. The joint is held down in the cooling mixture by two hooks at the bottom of the tray, and remains in for 15 or 20 minutes. The tray is entirely of gutta-percha and provided with four lugs for suspending, thus thoroughly insulating it for use during tests of joints in short lengths spliced up on board.

Meanwhile the further end of the new piece of cable in tank (on the near end of which the joint has just been made) is connected to the testing-room, and remains so connected, in order to test the cable as it is payed out, and communicate occasionally with the shore. From this end, when the joint is cool, a test is taken through the united cables, the end on

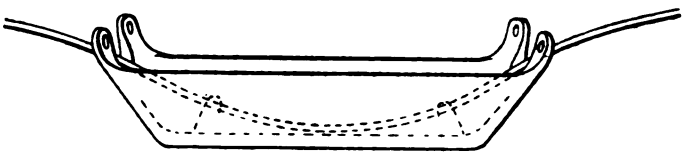

FIG. 42.—Joint Cooling Tray.

shore being free. The insulation of the seaward end, and that of the new piece spliced on being known, it is easily calculated what the two jointed together ought to give; and if the joint is not perfect the resultant insulation will be lower than this. But jointers very rarely fail to make a perfect joint, having served their time in the factory, where joints occur on every two miles of core manufactured, and being chosen as reliable men for sea work.

Preparations are now made for splicing the sheathing wires. The cable is stretched fairly taut, and at a convenient height for the men to work on it as they stand against it. As mentioned above, there is a considerable length operated on—about 90 feet—and stoppers are put on at this distance apart, by which to hold the cable in position while splicing. Messrs. Johnson and Phillips have introduced for this purpose the automatic stopper, shown in Fig. 43. The two jaws A A, which are hollowed out on the inside, and burred here and

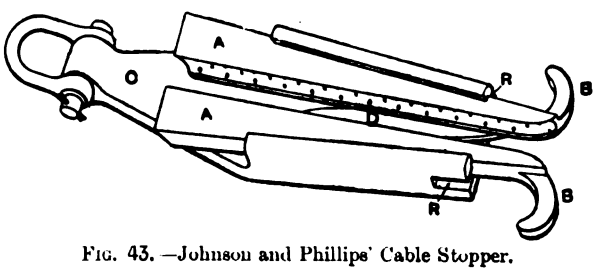

FIG. 43.—Johnson and Phillips' Cable Stopper.

there to grip the cable, slide longitudinally along the bed C between taper guides. The jaws are kept apart by the curved spring D, and if moved to the left towards the shackle, open to receive the cable. When tightened up from the shackle, the jaws close, gripping the cable.

(*To be continued.*)

Balata and Rubber in Guiana.—According to Mr. Consul H. Wyndham, of Paramaribo, the Balata industry, which has only lately become of any importance in Dutch Guiana, will probably grow. In British Guiana the export of "balata," which is attaining considerable importance, will, it is believed, be very productive for a time only, as there is no forest conservancy law in the colony, and parties who are granted tracts of land for the exportation of this product are uncontrolled in their method of drawing the milk, which results in trees being totally destroyed to get the greatest amount of milk by the most inexpensive and quickest method.

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THE USE OF WATER-POWER FOR ELECTRICAL PURPOSES.

BY NORMAN F. WILSON.

(*Concluded from page 194.*)

Mixed Flow Turbines.

These turbines are a combination of the inward and axial flow types. The water enters the wheel at the circumference, but instead of leaving at the centre it is brought round by a curve in the buckets, and leaves in a direction parallel with the shaft. Turbines of this type are mainly used and manufactured in America, but they are now becoming more common in Great Britain. Some of them give a very good efficiency and are most serviceable motors, but others are designed with a view to cheapness rather than to reliable and economical working, although the most extravagant promises are made. One of the peculiarities of most of these wheels is their small diameter and great width as compared with the inward and axial flow turbines

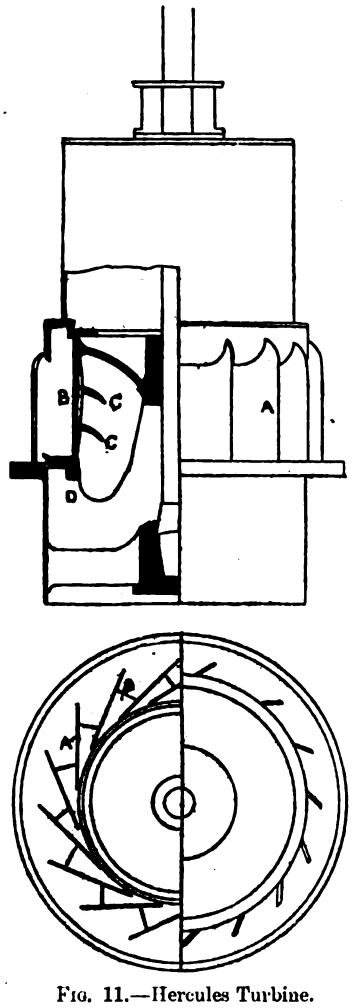

FIG. 11.—Hercules Turbine.

manufactured in England and on the Continent. These turbines are usually designed to work on low falls with a large quantity of water. Under these circumstances the fact of having a wheel small in diameter, making a greater number of revolutions per minute than most others, is often a distinct advantage for electrical work, as the speed of the line shaft is higher. Turbines of this type are not, as a rule, placed on falls higher than 40 or 60ft.

The Hercules and Victor turbines both give good efficiencies, and hold a leading position in the United States; we shall, therefore, take them as illustrations of this type. The water enters all round and is deflected by the hood in the bottom of the buckets, so that it leaves in a direction at right angles to that which it took on entering. Fig. 11 is a general view (part section and part elevation) of the Hercules turbine. Around the wheel is the circular guide-blade chamber, through which the water enters. When it is desired to work below the full power the annular sluice, B, which fits between the guide-blade, is lowered. The efficiency at part gate is good, as the small tongues of metal, C C, which are cast on to the buckets, practically shut the water off from the upper part of the wheel. The wheel then works as if it were designed for the smaller quantity, the upper part being full of comparatively still water. The water joint with the guide-blade chamber is formed at B by a ring which holds all the buckets firmly together. The guide-blade chamber rests on a short suction tube, on which is cast a footstep for carrying the shaft. These wheels are usually fixed at the bottom of the fall, but they can be placed on a horizontal shaft and work by suction if the situation render it desirable to do so.

The wheel of the Victor turbine is somewhat similar in design, but the method of regulating the guide-blades is quite different. The guide-blades are stationary, as before; but instead of the circular sluice or register gate being raised or lowered according to the supply, it is given a horizontal sliding motion by means of a spur pinion and sector, thus lessening the width of the guide passages instead of their depth. Victor turbines are frequently placed on a horizontal shaft, especially when they are used for driving dynamos. Since there is always a certain amount of end-thrust with mixed flow-wheels, it has been found most advantageous to place them in pairs back to back, as they then counterbalance one another. The difficulty with end-thrust is not, however, insuperable, and single turbines of this type work by suction very satisfactorily.

Tangent Turbines.

The essential difference between tangent turbines and the others which we have described lies in the fact that the water

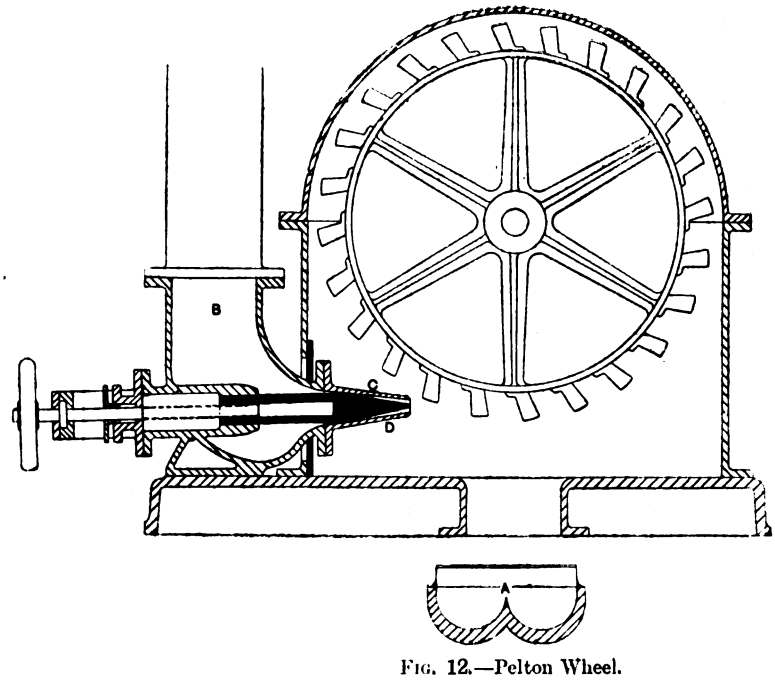

FIG. 12.—Pelton Wheel.

enters and leaves the buckets of the wheel in the same direction, instead of passing through them, as it does in all the other types. Instead of guide-blades, the water is directed against the wheel by one or more nozzles.

One or other of the four types of turbine already dealt with is applicable to almost every situation when water-power is available; but when the fall is very high the expenses of manufacture are often heavy, as the wheels have usually to be large in diameter, and the casings have to be of great strength and well stayed in order to withstand the pressure. Hence a demand has sprung up for an inexpensive turbine, which can be worked under a high fall at a comparatively small number of revolutions per minute.

Of all the turbines designed to meet these requirements the Pelton wheel (Fig. 12) has proved the most satisfactory; the cost is not great and the efficiency is good. In the Pelton wheel illustrated the supply pipe B terminates in a taper piece,

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to which the nozzle D is attached. This nozzle can be easily removed, and another of a different size substituted when desired. When the wheel is large, the pipe B may be extended so that two or three nozzles can be fixed to it. The gun-metal plug C screws into the nozzle when the wheel is not working. In the enlarged view of the bucket it will be seen that it is divided in the centre by the edge A. This edge separates the jet into two equal portions, one of which sweeps round each side of the bucket before leaving it. The wheel is shown mounted on a bed-plate, with a cast-iron cover over it to keep the water from splashing out.

Water Pressure Reducing Valve.

Considerable difficulty has often been experienced in working turbines on town mains owing to the pressure varying when more or less water is drawn off for other purposes. The

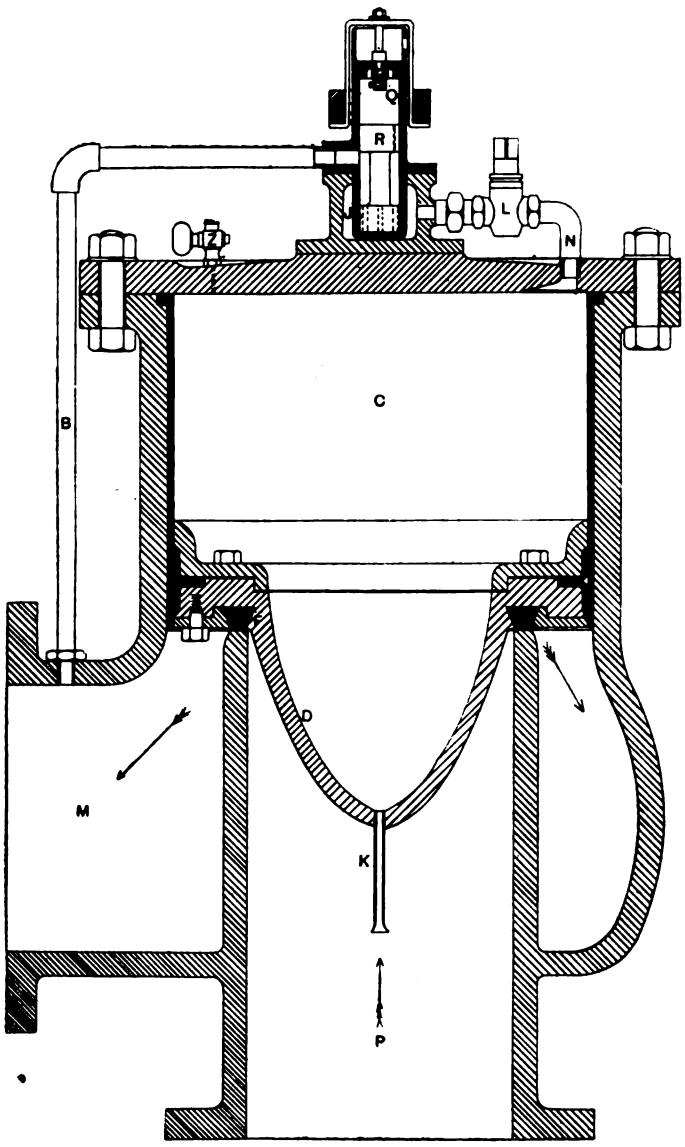

FIG. 13.—Reducing Valve.

turbine, of course, has to be designed for the medium pressure; and therefore, when the pressure rises, it begins to race, and may do a lot of damage to the dynamo or other machinery it is driving unless an attendant be constantly at hand. To obviate this difficulty Messrs. I. Braithwaite and Son, of Kendal, have brought out a reducing valve, Fig. 13, to be placed between the turbine and the supply main. The valve is weighted and designed to maintain a uniform pressure in the turbine case, no matter how much this may be exceeded in the pipes. The flange of the inlet pipe P is attached to the high-pressure main, and that of the outlet M to the turbine. The water passes in the direction indicated by the arrows, from P to M, and thence into the turbine. The piston D is provided with an india-rubber ring, which makes a water-tight joint when it is down. The area of the top of the piston D is twice that of the pipe P, and as the space C, above the piston D, is connected with P through K, the pressure in C would always be the same as in P, were it not that the water can get through the pipe N, and through the regulator and pipe B to M more quickly than it can come in through K. But it must be noted that the pressure from M, acting below a brass piston in the regulator, will raise the piston whenever the water contained below it has pressure enough to raise the weighted safety valve Q. (The water has access to the chamber above it by the very small hole R). As the brass piston rises it closes the holes J J, and presently the passages, which were originally in the aggregate larger than K, become less than K. The pressure in C then increases, and pushes the piston D down, thereby throttling the water, and reducing the pressure in M until it can no longer lift the safety valve Q. If the cock L be shut, the full pressure from the supply is immediately realised in the space C, and the valve is at once closed without the labour usual in shutting a large valve under high pressure. The pressure on M is regulated by adjusting the annular cast-iron weights on the safety valve Q. By the use of such a valve as this it is possible to run dynamos direct on to the circuit without the risk of the lamps being burnt out. When the reducing valve is at work with the ordinary pressure there will be a reduction of the available head equal to about 5 per cent. of the total. When the pressure rises there will be no more loss than with an ordinary valve, since the water would have to be "wire-drawn" in any case. The slight loss in efficiency is, however, amply compensated by the regularity in the speed of the turbine.

THE ST. JAMES' AND PALL MALL COMPANY'S MAINS.

The following correspondence has been addressed to us for publication:—

SIR: I beg herewith to enclose you copies of correspondence which has passed between my Company and the Board of Trade on the subject of certain damage to a gas meter, &c., and alleged to have been caused by a leakage of electricity. As the letter of the Gas Company to the Board of Trade was published and commented on by the gas journals before the matter was brought to the notice of my Company, I should esteem it a favour if, in the interests of the industry, you would give prominence to the matter in your journal.—Yours, &c.,

F. J. WALKER, General Manager and Secretary.

The St. James' and Pall Mall Electric Light Company (Limited),
Mason's-yard, Duke-street, St. James', S.W.,
June 29, 1892.

Board of Trade (Railway Department),
London, S.W., May 19, 1892.

ST. JAMES' ELECTRIC LIGHTING ORDER, 1890.

SIR: I am directed by the Board of Trade to transmit to you, for any observations which your Company may desire to offer, the accompanying copy of a letter which they have received from the Gas Light and Coke Company with regard to an alleged case of damage arising from an escape of electric current.

I am, Sir, your obedient servant,
(Signed) R. GIFFEN.

The Secretary the St. James' and Pall Mall Electric Light Company (Limited).

The Gas Light and Coke Company, Horseferry-road,
Westminster, S.W., May 4, 1892.

SIR: The Directors instruct me to enclose for your perusal the accompanying copy report of their distributing engineer to another case of damage arising from an escape of electric current.

I am, &c.,
(Signed) J. O. PHILLIPS,
Secretary and General Manager.

The Secretary Board of Trade.

[COPY.]

J. O. Phillips, Esq.

DEAR SIR: I have another case of damage to a meter and fittings by electric current in the district of the St. James' and Pall Mall Electric Lighting Company, viz., at 56, Pall Mall. We have a ten-light check meter fixed at the top of w.c. in bath-room on second floor, near to a small cistern, the water supply pipe of which touches the back of meter, and there are electric fittings near the meter. The gas is used for heating purposes only, and is now, by request of consumer, temporarily dispensed with.

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On the 25th ult. the occupier was startled by the noise of an explosion. The housekeeper saw smoke in the passage, and, noticing a smell of gas, at once turned the tap off at the meter. Meter and fittings are damaged, likewise the coruice and ceiling. Apparently there was a small escape of gas on consumer's fittings, and this was evidently ignited by the electric current. Our inspector informs me that he subsequently saw electricity issuing, in the form of a blue spark an inch long, from the electrical fittings at the point in question. The ignited gas melted the solder on the top of the meter, and also the lead inlet pipe.

I cannot too forcibly call attention to the dangers these electric wires present to our fittings. They arise in such a variety of ways hitherto unsuspected by electrical engineers and also, I apprehend, by insurance companies. The risk of fire being attributed to us, when all evidence of the real cause may be effaced, is a very grave one to my mind.

I am, &c.,
(Signed) G. F. L. FOULGER,
Distributing engineer.

The Gas Light and Coke Company, 146, Goswell-road, E.C.,
May 3, 1892.

Both gas and electric fittings work was executed by Messrs. Liberty and Co. of Regent-street.

The Assistant Secretary (Railway Department),
Board of Trade, London, S.W., May 31st.

ST. JAMES' ELECTRIC LIGHTING ORDER, 1890.

SIR: I beg to acknowledge receipt of your letter of the 19th inst., enclosing to my Company a copy of a letter received by the Board of Trade from the Gas Light and Coke Company (Limited), on the subject of an alleged case of damage arising from a leakage of electric current.

On receipt of your letter inquiry was made by this Company, and the facts of the case were found to be as follows:—The gas meter in question was placed on the top of a w.c. in the bath-room of a set of chambers at No. 56, Pall-mall, and was used to register the supply of gas to a stove in the sitting-room, the chambers being lighted throughout by electricity. The supply terminals of my Company with the main meter are situated in the basement of the house, and from this point the landlord's distributing wires are carried through the house for the supply of various sets of chambers. Although the fittings on these premises were put up a few years back, and are not of the most modern description, the insulation of the whole of the circuits in the house is in proper condition. We learn from the landlord that at the time of the accident complained of the tenant of the chambers was in his sitting-room, with the gas stove burning, and that he heard a slight report, the stove being extinguished at the same time. No notice of this appears to have been taken for some few minutes, when, on account of a smell of burning, someone went into the bathroom, and found the damage as described. The gas was at once shut off. In the report of the engineer of the Gas Company it is stated, "that there was a small escape of gas on the consumer's fittings, and this was evidently ignited by the electric current. Our inspector informs us that he subsequently saw electricity issuing in the form of a blue spark an inch long from the electrical fittings at the point in question."

We are informed by the landlord that there was known to be a leakage of gas at the junction of one of the pipes to the meter; but we must protest in the strongest terms against the statement that this gas "was evidently ignited by the electric current." With regard to the "blue spark seen at the point in question," the landlord, who was present with the gas inspector at the time, explains to us that this was seen in the sitting-room, where there is fitted an ordinary Edison tumbler switch. With this switch, as with most other forms, it is possible by moving the tumbler slowly across or by removing the metal cover so as to place it across the switch terminals, to somewhat exaggerate the usual spark at a switch on breaking contact. We need make no further comment on this statement made by the Gas Company, which is put forward by them as evidence in support of a charge both rash and ill-considered. Had the leakage of gas been fired by an external spark as described above, the effect of an explosion would have been visible in the room.

As regards the condition of the electric circuits, the whole of the premises were tested *en bloc* for leakage on the 28th ult., in the course of the usual quarterly tests, and were found to be in order. For the purposes of our inquiry an insulation test was made on the 23rd inst. again from the consumer's terminals, and the insulation resistance of the whole of the circuits to "earth" was found to be 1·18 megohms. The electric fittings had not been altered or disturbed in any way. Apparently the damage was caused by firing back from the stove to the gas leak close to the meter, which then continued to burn. We are informed by the landlord that he does not for a moment think of attributing the damage in any way to the electric circuit, and, further, that when the officials of the Gas Company inspected the premises they were accompanied by an expert engaged by them, who declared at the time in his hearing that he could see nothing in the electric light work that would account for the damage, and suggested that it would have been caused by firing back from the gas stove itself, an accident by no means improbable.

I am instructed, therefore, to ask, in view of the uses to which this incident has been put to prejudice the interests of the industry, that an inquiry should be held in the matter. My Company are not aware as to whether Major Cardew has already made an inspection, as in the previous instance; but they would request that an early appointment be made for him to meet Prof. Kennedy, F.R.S., who has kindly consented to act for the Company in this matter. I am further directed to draw the attention of the Board of Trade to the statements contained in the copy of a paper enclosed herewith, and to point out the uses to which every purely gas accident, such as the above, will be put, unless reasonable facilities are afforded to the various electric light companies to be represented at any official inquiry, and to examine into the cause of any damage within something less than four weeks from the time of its occurrence.

I am, Sir, your obedient servant,
(Signed) F. J. WALKER,
General Manager and Secretary.

Board of Trade (Railway Department),
London, S.W., June 21, 1892.

ST. JAMES' ELECTRIC LIGHTING ORDER, 1890.

SIR: With reference to your letter of the 31st ultimo, on the subject of the damage arising from an explosion of gas at No. 56, Pall-mall, alleged to have been caused by a leakage of electric current, and asking that Major Cardew may be instructed to meet Prof. Kennedy, F.R.S., with a view to a joint inquiry into the circumstances attending the explosion, I am directed by the Board of Trade to inform you that Major Cardew has visited the premises in question, and reported that, in his opinion, there was no evidence to establish any connection between the electric supply of your Company and the small explosion of gas in question, and that in these circumstances the Board of Trade are of opinion that no formal inquiry is necessary.

I am, Sir, your obedient servant,
(Signed) COURTNAY BOYLE.

The General Manager and Secretary, St. James' and Pall Mall Electric Light Company (Limited).

ELECTRICITY AT THE ROYAL AGRICULTURAL SHOW AT WARWICK.

A careful inspection of the Royal Agricultural Show at Warwick reveals the fact that as yet "the application of electricity to agriculture does not exist." It is true that in the show yard are a few dynamos, a few lamps running in broad daylight at unknown voltage, a few spasmodic arc lamps demonstrating the irregular motion of a gas engine; but nowhere do we find the electric cow milker, or the electric curd depositor, or the electric seed raiser, all of which will no doubt some day do for agriculture what the electric furnace has done in metallurgy, or the electrolytic bath has done for metal refining. Magnetism—electro magnetism, indeed—makes a little show; this, perhaps, is the precursor of more, in the form of two magnetic separators for extracting iron and steel from bones, oilcake, &c., before putting them into grinding mills or disintegrators. The first machine is that shown by Mr. J. Harrison Carter (Christy Carter patent), and consists of a barrel revolving, having on its exterior surface projecting poles, alternating north and south; on the top of this barrel are fed the materials containing iron, and any iron coming in contact with the poles adheres, and is carried round and dropped into a separate receptacle by the demagnetisation of the magnets by cutting off the current by a commutator. Considerable science is shown by the very successful removal of sparking at the commutator by the proportioning of the coils, and of the solid copper sheathing round the magnets on which they are wound. The machine takes 40 volts amperes to magnetise it, and will deal with about two tons of bones per hour. Its weak point seems to be that if a piece of flat iron, say, happens to fall on the drum with a non-magnetic body in between it and the pole piece, it will not adhere; and one miss renders a machine of this kind useless, as the disintegrating mill is seriously damaged. Another machine, shown by the Hardy Patent Pick Company, of Sheffield (Atkinson Elliott patents), is an improved form of a somewhat similar machine shown last year, and is devised to overcome this objection. It consists of a hollow inclined drum, through which the material is fed. The interior surface presents a series of poles, magnetised through half a revolution in such a manner as to pick up and deposit in a tray any magnetic material. In this machine, as it takes about ten revolutions for any particular piece of material to pass through, and there are ten poles, one hundred chances occur for any piece to be caught. We understand that in many months' use of one of these machines by the Farmers' Company at Hull, no piece of iron has passed through; and pieces of all sizes, from a hair-pin to a hatchet-head, have been extracted. These machines are also used for taking miners' wedges and picks out of coal before grinding for coke-making. This machine takes 100 volts 7 amperes to magnetise it. It was magnetised by a small Goolden dynamo.

Among dynamos shown in connection with gas or oil engines running lights were to be noted a well-finished machine by Newton and Co., Taunton, driven by a Priestman oil engine, the lamps used being 50 c.p. Edison focus lamps; a small dynamo by Holmes, driven by a Trent gas engine; a Tyne dynamo, by Messrs. Scott and Mountain (Limited), driven by a Robey oil engine; a small Kapp dynamo, by Messrs. Johnson and Phillips, driven by a Hornsby-Akroyd oil engine.

We hope next year to see some advances in the direction of applying electricity to agriculture, for certainly in few directions is there so large a scope open,

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CLUB LIGHTING.

Political economy is said to be intended only for theoretical study; and economics, according to some authorities, are profitable only in so far as they analyse past history. To apply these sciences to the present is too often misleading, and to attempt by their aid to forecast the future is rarely advantageous. But there are one or two maxims which inspire a confidence as complete as that which is justly placed in OHM's law; and the exceptional cases in which this confidence appears to have been misplaced are so rare that they need hardly be considered. One of these is "the price of a thing is what it will fetch." It may be fatalism or it may be optimism, but it is perfectly certain that this law will hold its own in the long run. "The position of copper" is a favourite theme for financial journals when there is nothing doing in other matters, not even perhaps in the copper market. Truly as this simple law is followed during the rise, continuance, and inevitable collapse of a "ring" or "corner," so surely also does it predict the return to equilibrium of normal price, unless indeed a real monopoly is established. It may at first appear that a monopoly destroys the simplicity of this law, but it really includes the principle of supply and demand, and the special case of monopoly value. The price of a monopoly is theoretically fixed at that which will give the producer the maximum profit.

There have been many grumblings about prices in the electrical industry, and it has been often suggested that the price of dynamos and lamps is too high, and that cable rates and the price of the supply of electrical energy are artificially maintained at a point which is felt to be grievous by the consumer, and therefore unjustifiable. The latest grumble comes from a number of Secretaries of clubs who recently held a meeting at White's to discuss the question of the

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heavy charges which are being made by the electric lighting companies for the supply of the electric current. The following clubs were represented, all of which use the electric light:—White's, Devonshire, Travellers', Windham, Reform, Orleans, St. Stephen's, Conservative, Brooks's, Junior Army and Navy, Thatched House, National, Oxford and Cambridge, and Prince's. A deputation from the meeting was appointed to wait upon the directors of the companies supplying these clubs, to request that a considerable reduction should be made in the charges, which, it was agreed unanimously, had become most onerous.

It is well known that a club is a most valuable customer to a supply company. Comfort is generally studied, and that implies not only plenty of light, but light arranged in a comfortable manner. It cannot be denied that while electric lamps can be placed in any position whatever, and provided with any kind of shade, it is no easy matter to secure comfort and economy simultaneously; and unless the lamps are arranged with considerable care, a good deal of current is wasted. Besides this waste, which may be avoided, there is the unavoidable length of time during which the light is required. Most of the lamps in a club are in use continuously from dusk until the hour of closing. The average number of hours a day during which a lamp is used in a club is very much greater than in most other establishments; and it is on this, perhaps, rather than on account of the large number of lamps, that clubs are valuable customers. The facility for turning on and extinguishing the lights, which is a feature of so great convenience in domestic lighting, is hardly felt in a club. The main advantage to the members is the coolness, and to the proprietors the cleanliness. The coolness must be looked upon as a luxury, and paid for naturally at a price higher than gas; but the absence of dirt ought to be clearly appreciated, and the saving in cleaning and decoration ought to be distinctly realised. When these two points are considered, the increased cost of electric lighting, even if the convenience be not considered, is not so heavy as appears to be imagined. It is difficult to understand why the charges made to these clubs should have "become most onerous," unless, indeed, it be due to the termination of annual contracts and the introduction of meters. Several very bad bargains were made at first, and the supply companies have been only too eager to terminate them and to fix meters. While contracts have been running there has been no inducement whatever for the managers of clubs to economise in the use of their lights; and careless use of electric light when and where it was not really wanted, has tended no doubt to increase the bills. Sir F. Bramwell has pointed out that the great convenience to which we have already referred, viz., the facilities for turning lamps on or off, really contributes largely, under proper management, to economy; and it is to the careful extinguishing of lamps when not wanted that he attributed the fact that, in his case at any rate, electric light cost very little more than gas had done. Under contracts, this art of economising has not been studied, and hence, no doubt, much waste arises. Prices will be spontaneously lowered, and it is announced that from to-day the Westminster Company have reduced their standard price to 7d. Most companies offer important rebates to large customers, and no doubt further concessions will be granted, especially to such applicants as the Secretaries of important clubs. But as long as electrical energy is found to fetch 7d. per unit, that will be the price for ordinary customers; and unless the supply companies are found to be doing so well that the Board of Trade finds it possible to reduce the maximum price (which they are empowered to do every seven years) anybody who gets a rebate should be thankful for it.

REVIEWS.

The Electromagnet, and Electromagnetic Mechanism. By Silvanus P. Thompson, D.Sc., B.A., F.R.S. (London: E. & F. N. Spon. 1891.)

Although by no means such a weighty contribution to electro-technical literature as that *magnum opus*, the Fourth Edition of "Dynamo-Electric Machinery," the present volume is none the less valuable. Electromagnets and electromagnetic mechanisms have always had a peculiar fascination for the amateur; and bearing this fact in mind, no doubt, the author has adopted throughout an almost popular style. Both the telegraph and the telephone engineer, however, are interested in electromagnetic devices; and the author, therefore, spares no pains in making the laws of electromagnetism plain sailing for them, at the same time that he exposes for the benefit of the student the innumerable fallacies and popular superstitions which have so long encumbered this corner of physical science.

"It is the aim and object of the present work," the preface tells us, "to show how the same considerations which have been applied with such great success to the subject of the design of dynamo-electric machines may be applied to the study of the electromagnet. The theory and practice of the design and construction of electromagnets will thus be placed, once for all, upon a rational basis." We think there can be no gainsaying that the author has attained his object, and that both those who are occupied in the electrical industries, and those who follow science for its own sake, will benefit by a perusal of this work. It is, indeed, a matter of no little congratulation that English men of science of the first rank are still to be found willing to devote their time to the somewhat thankless task of book-making. In ordinary every-day literature one occasionally comes across an author whose style is such as to render his readers almost oblivious to the poverty of his matter. Teutonic writers, on the other hand, have much to say but seldom an attractive style. No scientific writer has, perhaps, ever erred in the former direction; though the name of those who have disheartened their readers by their diffuse verbosity is legion, while those who have succeeded in hitting the golden mean may be counted on one's fingers. We have, indeed, met with perverse individuals who hold that the paths of knowledge may be too smooth, and who prefer an obscure style, since "it makes men think for themselves." It is satisfactory to find that the author of "The Electromagnet" is not in favour of erecting such artificial barriers against the attainment of truth. It is to be regretted, however, that he has allowed the otherwise admirable lucidity of this work to be in some degree marred by constantly ringing the changes on inch and centimetre measure, and by the retention of the direct form of address, as to an audience. National individualism, long use, and the custom of the trade may make "the inch" a necessity in electro-commercial dealings; but, for heaven's sake, do not let us encourage laziness and promote scientific isolation by interspersing $\mathfrak{B}$'s with $B_{\frac{1}{2}}$'s. If English electrical engineers really must have their magnetic inductions in lines per square inch, the $B_{\frac{1}{10}}$s, &c., might, at any rate, be relegated to an appendix. Again, to be suddenly told, as we are on page 205, that we are "smiling" when conscious of having done nothing of the kind, and again, on page 213 and elsewhere, that "the spot of light on the screen is reflected from my galvanometer at the far end of the table," reads somewhat queerly in the middle of a serious volume on electromagnetism. The author also displays a decided liking for new terms. When "grave and reverend seigniors" talk of *quads*, *secohms*, and *henries*, not to mention *permeance*, *remanence*, and *reluctance*, no wonder lesser lights try their "'prentice hands" at *thoms* and *gausses*, and similar scientific slang, until a glossary threatens to become an indispensable adjunct to every electrical publication.

We will conclude our notice with a brief enumeration of the contents. The history of the subject is summarised in the Preface and in Chapter I. The elementary principles and fundamental phenomena of electromagnetism and the magnetic properties of iron are then dealt with. In Chapter IV. the

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law of the magnetic circuit and the law of traction are gone into at considerable length, and the bearing which they have on various magnetic paradoxes is clearly pointed out. The succeeding section is mainly devoted to a consideration of magnetic leakage, and is followed by chapters on the winding of electromagnets, and on rapid-acting electromagnets. Prof. Thompson is never so happy as when engaged in stamping out heresy, and the law of inverse squares as applied to the pull of an electromagnet on its armature is, we are informed on p. 161, "not proportional to the distance, nor to the square of the distance, nor to the cube, nor to the fourth power, nor to the square root, nor to the three-halfth root, nor to any power of the distance whatever, direct or inverse." . . . Chapter VIII. is devoted to the mechanism known as the coil-and-plunger, all the vagaries of which are shown to be explained by the law of the betterment of the magnetic circuit, and the integration of larger B^2 over a smaller area. Succeeding sections deal with the leading varieties of electromagnetic mechanisms; and the book closes with a long and exceedingly interesting chapter on permanent magnets, the latest researches on the relation between temperature, chemical condition and magnetic property being succinctly set forth.

The Mechanical Engineer's Pocket-Book. By D. K. Clark. (London: Crosby Lockwood and Son. 1892.)

Although we received this book so long ago as December last, we have no apology to make for delaying a review for so long a time, since we have during the past six months constantly used it, at first for trial, and afterwards on account of its real merits, and from this experience can testify to its great value. It is impossible to judge of a book of reference by a glance through its pages, and one cannot sit down and read straight through a book of this kind. If a pocket-book is to please—not everybody, perhaps, but a large number of readers—it is manifestly improbable that any one of them will find that it contains just what he wants and no more. It is better, then, to err a little on the side of versatility, and this is, perhaps, done in the present work. It is preceded by a full and clearly arranged list of contents, and is concluded by a good index. An "introduction to the tables," after the plan of Chambers, is followed by an excellent table, which has for many years been used in Continental books, giving circumferences, circular areas, squares, cubes, square roots and cube roots of any number of diameter, on a single line. The table of logarithms is not easy to use, and should be divided into sets of five lines. The trigonometrical tables are continued straight on from 0° to 90° without the usual confusing retrograde arrangement after 45°. Sines and cosines are given in one table, and tangents and cotangents in another, both going to half degrees. A short table of trigonometrical relations should be added. The weights and measures are very complete—if anything, rather too miscellaneous. A large number of compound and collective tables are given, showing, *e.g.*, 1lb. per lineal yard = 0·7857 ton per mile. The metric tables are very complete, and many compound equivalents are given; such as 1lb. per cubic foot = 16·02 kilos. per cubic metre. An excellent table, No. 86, of specific gravities, is made rather confusing by being arranged alphabetically, gold coming next to glycerine, and palladium to petroleum; but classified tables are given in addition. Weights of a large number of forms of manufactured metal are given, *e.g.*, bars, tubes, rolled joints. A section on the strength of materials is full of useful formulæ and tables. We notice that a paragraph devoted to Hadfield's steel does not allude to its non-magnetic quality. A short section gives some rather antiquated information about electric transmission of power; a brief and very disparaging paragraph deals with electrical propulsion on railways; and one on electric traction is confined to a brief description of the Bessbrook-Newry line. The sections on mechanical principles and heat are very valuable, but we have no space to enumerate all the best parts of the contents. The section on the measurement of a stream of water is open to the same criticism which was applied in these columns by Mr. Geipel to Mr. Wilson's article, viz., that no reference is made to the correction for contraction at the edge of the bay, and no allusion is made to the V notch. In a book professedly for mechanical engineers, the concluding section on electrical engineering, which has been contributed by another author, might well have been omitted altogether, especially as it is altogether inferior to the rest of the work. A paragraph on accumulators says that "the acidulated water contains 25 per cent. of sulphuric acid," and does not give a word about the specific gravity. The precept that "the charging electromotive force should not exceed the electromotive force of the accumulator by more than 5 per cent." would have been welcomed as evidence by Mr. Lane Fox in the recent trial. "The accumulator cells," we are told, "should be kept in as dry (but not warm) situation as possible." The experience of central station managers is opposed to this. The diagrams from the earlier edition of "Dynamo Electric Machinery" are reproduced, showing the connections of dynamo fields, together with some of the least useful formulæ of that work. Many of these refer to efficiency, and after all, we read that "a good dynamo should have a commercial efficiency of at least 50 per cent." With the exception of the strictly mechanical tables of, say, telegraph wires, the whole of this section might well be omitted, especially as Mr. D. K. Clark does not seem to entertain a very high opinion of electrical engineering. As a mechanical engineer's pocket-book it is a most important addition to its class. The binding and type are of the very best, and may be said to be both comfortable and handsome. It opens like an ordinary book, but having rounded corners can easily be carried in a fairly roomy pocket, if necessary.

Lantern Slides of Faraday's Original Apparatus.

It is always interesting to see the actual tools with which great workers have worked, and to handle and re perform classical experiments with the very means with which some original genius first obtained a glimpse of unexplored regions of fact. When the pathway has become worn by the passage of many feet we are often unable to realise the slender clue which conducted the first explorer to the mountain top; and an intelligent student will always, therefore, appreciate an opportunity of examining the historical facts of the science he is studying. The next best thing to seeing the objects themselves is to see good photographs. We have before us a series of twelve lantern slides, prepared by Miss K. M. Reynolds, giving actual photographs of each of the principal pieces of apparatus employed by Faraday in the discovery of electromagnetic induction. These rings of iron, pasteboard tubes wrapped with hand-covered wire, and other relics treasured in the museum of the physical laboratory of the Royal Institution, have been separately photographed on glass (by permission), and Miss Reynolds has arranged a set of slides which will be found useful to teachers and lecturers. The set also includes a photograph of Faraday's historic magnets, with which the diamagnetic experiments and the magneto-optic work were performed, and a view of the laboratory and lecture theatre. The set of twelve lantern slides can be procured directly from Miss Reynolds, Southover, Heene, Worthing (price £1), and appended to each slide is a reference to the passage in the "Researches on Electricity" in which mention is made of the object represented. J. A. F.

Electrical Instrument Making for Amateurs. By S. R. Bottone. Fifth Edition. 1892. (London: Whittaker and Co.)

If an amateur were already a fair electrician and passable workman he might get a few useful hints in rough instrument making from the above book. To the beginner, for whom it is apparently written, it should only be given on the understanding that he is to accept no theoretical statement in it unless confirmed by some good authority, and is not to place too great reliance on the practical directions. Without such warning he might think that it was currently accepted that "according to our present knowledge the phenomena we group together under the name of electricity (*sic*) are simply manifestations of a peculiar mode of motion of atoms" (p. 121); or that "the arc itself sets up a back current (!), having an E.M.F. of 39 volts." He might also believe that a good rule for safe working current is to allow 2,000 amperes per sq. in. for copper of any diameter (between Nos. 6 and 22 at any rate), irrespective of depth of winding,

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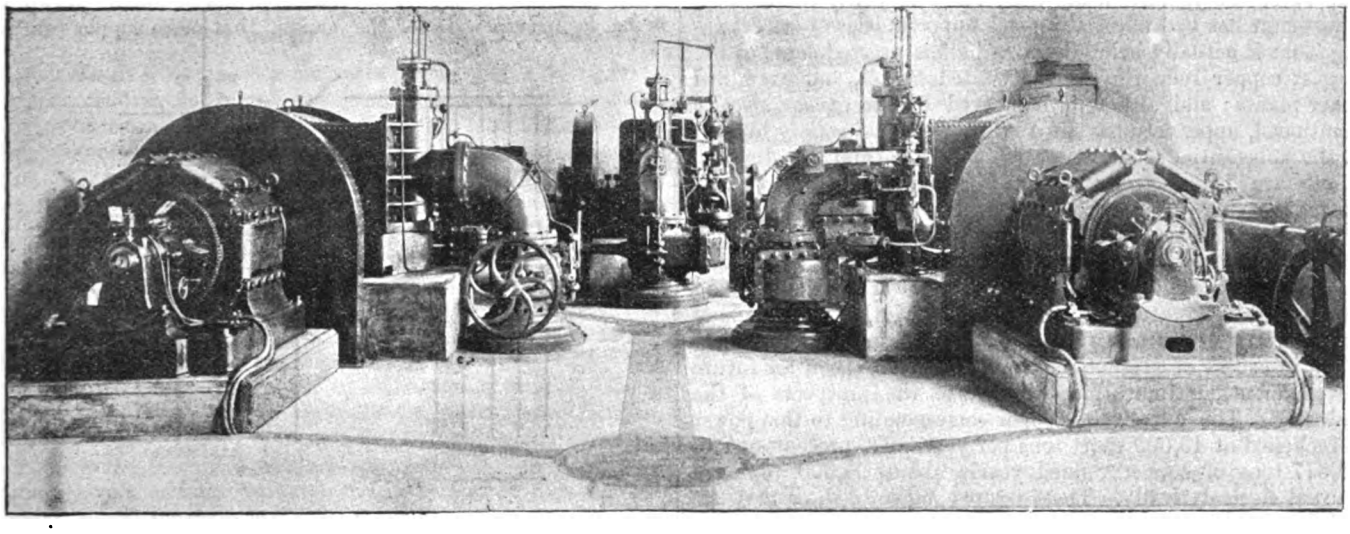
or whether it is to be used on a field magnet or an armature. The author is careful to state, however, that this only refers to *commercial* copper—he has tested samples of pure copper, which will carry nearly twice as much (pp. 113-200). As to practical instructions, the amateur *may* make a good and tight job of a three-cell accumulator box made out of sheet gutta-percha sealed up with a hot poker—on the other hand, he may not; but we are certain he will never live long enough to finish calibrating an ammeter in the way Mr. Bottone tells him to (p. 118). As an example of how to go about a simple and straightforward job in the most difficult and hopelessly unpractical way we have never yet seen its equal.

Professional Papers of the Corps of Royal Engineers. Edited by Captain W. A. GALE, R.E. Vol. XVII. (Chatham: Royal Engineers Institute.)

This volume, which is chiefly devoted to a Paper by Major E. C. S. Moore on Sanitary Engineering, contains some useful information relating to Webster's process of electrolytic sewage purification, including a report by Sir Henry Roscoe.

ELECTRIC LIGHTING IN SWITZERLAND.

There has recently been installed at Geneva a gigantic water-power plant. The turbines, which are situated on a small island in the middle of the Rhone, are principally used for furnishing power to a central station supplying the electric light to the town. It was found necessary to place this station 350 metres above the hydraulic house, resulting in an unavoidable loss of power. The Société d'Appareillage Électrique of Geneva have just terminated negotiations for the entire lighting of the town by electricity; and it would not be out of place to say something about their present plant, which will soon be known as the Ile at Geneva, contains eight dynamos, giving 600 amperes at 110 volts, and two extra dynamos of 115 E.H.P. The distribution is carried out on the three-wire system. Each cable encloses three separate conductors of the same size, and the current generated by the central station is delivered by five special feeder cables. The five feeders have a total length of some 3,000 metres. The distributing mains are about 3,500 metres long. Some 2,000 metres of other cable brings the total length up to some 25½ kilometres. The whole of the cables are underground.



View of a portion of the Geneva Hydraulic Electric Lighting Station.

doubled and trebled to meet the requirements of the place; Geneva will then have the largest installation in Switzerland.

In 1708 Geneva had a hydraulic plant installed on the left arm of the Rhone. The last vestiges of this disappeared in 1884, on the deepening of the river; and the present magnificent hydraulic station was commenced in 1883, under the direction of M. Turettini, the pumps being built by E. Wyss, of Zurich; Weibel and Briquet, of Geneva, furnished the overhead trolleys, the total horse-power capable of being developed by the turbines being nearly 5,000. The water is distributed at high and low pressure. For supplying the electrical central station, 12 to 15 centimes per H.P.H. is charged according to the consumption. Nearly 1,000,000 francs have been spent on the station and service. These hydraulic works, which belong to the town, have entailed an outlay of 6,000,000fr. and more, and 160,000fr. is required annually for maintenance. Still there is a yearly profit of some 200,000fr. In 1891 the total amount of water supplied was 27½ million cubic metres (6,050 million gallons).

A new project for utilising the power of the Rhone on a vast scale has just been presented to the authorities. The promoters state that they will put down machinery of the biggest type ever made, to realise 12,000 H.P. (15 turbines of 800 H.P). The site is 6 kilometres from Geneva, near the junction of the Rhone and Arre.

The present central station (see Illustration) on what is

Up to the present the lighting at Geneva is nearly all private. Some 10,000 glow-lamps are divided among nearly 350 subscribers. The total value of the central station and plant is put down at near 890,000fr. Salaries of electricians and other *employés* amount to 25,000fr. yearly, and an additional 25,000fr. per annum is spent on the water-power. The progress of electricity in Geneva is well shown in the annual report, 22½fr. per share being the last dividend declared. No fewer than 2,200 lamps are installed at the Geneva Theatre—a beautiful building, modelled after the Paris Opera House. A quarter of these are of 10 c.p., 160 of from 31 to 50 c.p., and the others are of 16 c.p.

The following are a few particulars of the supply prices:—per 8 c.p. lamp-hour, 4 centimes; 16 candles, 7 centimes; 32 candles, 12½ centimes; 50 candles, 18 centimes; 100 candles, 35 centimes. The arc lamp hour is rated at 10 centimes per ampere. The consumer has to pay for the installation of his meter, being charged at the rate of six francs for one meter, nine francs for two, twelve francs for three, and so on, increasing three francs for every additional meter. The 12-ampere meters cost 25 francs yearly, 25 amperes 30 francs, 50 amperes 40 francs, and 100 amperes 50 francs. These prices include maintenance. Subscribers have to pay a minimum annual sum of 150 or 250 francs per year per lamp, according to the nature of the places lighted. Payments are made monthly, persons who pay promptly are allowed a discount of from 5 to 17 per cent., according to their agreement.

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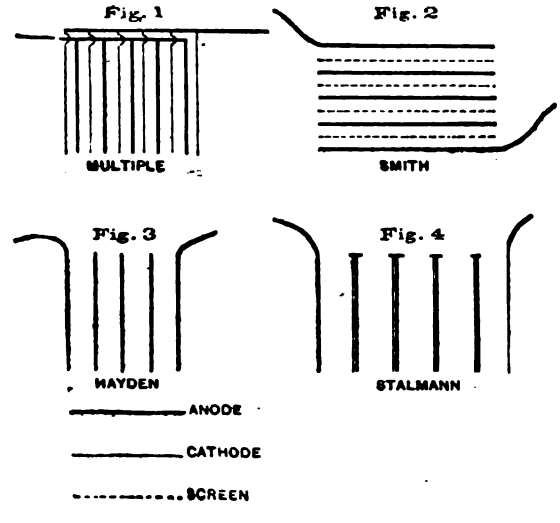
AMERICAN PRACTICE IN THE ELECTROLYTICAL REFINING OF COPPER.

Much needless mystery has been made about the details of the electrolytic refining of copper on a large scale, to the undoubted detriment of exact knowledge on the subject, and, consequently, to the money interests of those practising it. The reason is indicated in Dr. Gore's work on the "Electrolytic Separation of Metals," published in *The Electrician* Series, and may be assigned to the ignorance of manufacturers, of existing information open to all, and their consequent belief that the practical details each has worked out for himself are precious possessions not lightly to be parted with. Such inaccurate conceptions are inevitable wherever there is an indifference to, or ignorance of, general principles which alone suffice to link together isolated observations otherwise restricted in signification, or altogether incapable of interpretation. Under these conditions authentic information, from whatever source, is valuable, and its dissemination a praiseworthy undertaking.

The state of progress of the electrolytic refining of copper in America forms the subject of a Paper by Mr. F. B. Badt, read before the June meeting of the American Institute of Electrical Engineers—of which we have received an advance copy—in which the general though irrational dislike of publicity is illustrated by a quotation from Dr. Gore's book having the import of the remark made above, and is justly condemned. The writer has had unusually good opportunities of ascertaining what is actually being done, as he has erected some of the largest copper refineries in the United States, and examined other plants; and although hampered by the causes already mentioned, appears to have spared no pains to satisfy himself of the substantial accuracy of his statistics and conclusions. There are 14 electrolytic copper refinerles in the United States, varying in size from one having a dynamo capacity of nearly 500 kilowatts to the small installation where the refined copper is merely a bye-product from some other manufacture, using only some 6 kilowatts, the total power available being about 1,800 kilowatts. It must be stated that the whole of this power is not in use, plant having been, in some cases, put down in excess of present requirements in provision for future development, an indication in itself of the prospects of the industry. The output of copper corresponding to this power is reckoned at 43,000 short tons per year. At present out of 78,847 tons of copper refined yearly about 25,000 tons are treated electrolytically. These figures suffice to show that the industry is of considerable dimensions, and is not a mere addendum to the ordinary dry method of copper refining.

The arrangement of electrodes in favour in the United States refineries frequently exhibits a departure from the ordinary multiple system, special methods, named after their inventors, being in vogue. They are shown diagrammatically in the accompanying figures, together with the multiple disposition (Fig. 1) for comparison Fig. 2 represents the Smith arrangement, in which the electrodes are placed horizontally, a screen of cotton cloth being interposed between each pair. The top plate is made an anode and the bottom plate a cathode, the intermediate plates being unconnected directly to the dynamo. In consequence the upper surface of each plate becomes a cathode and the under an anode, the plates growing on the upper side and being eaten away on the under, until the whole of the impure metal has been dissolved and an equivalent of pure copper substituted for it. The impurities which do not dissolve are separated in the ordinary way, and are prevented from contaminating the clean freshly deposited copper by being caught on the screens of cotton cloth. Two refineries representing an output of 1,560 tons per year use this method. The Hayden process, which is cursorily mentioned by Gore ("The Electrolytic Separation of Metals," p. 186), is illustrated at Fig. 3, and differs from the Smith arrangement only in having the electrodes placed *vertically* instead of *horizontally*, thereby dispensing with the necessity for screens. It is in use in the refinerics having a capacity of 18,000 tons per year. In each of these devices the disadvantage accrues that the anode has to be completely dissolved and built up again from the other side before it, or rather the cathode which has replaced it, can be removed and worked up as refined copper; and to ensure that this is the case and that there is no crude copper representing the remainder of the former anode, the process must be carried on somewhat farther than would be necessary if the anode and cathode were not one and the same piece of metal, causing a certain wasteful expenditure of current in merely transferring pure copper from one plate to another if the limit be in the slightest degree overstepped. This difficulty is overcome by the plan adopted by Stalmann, who uses the same vertical arrangement as Hayden, but instead of plates of crude copper between the end anode and cathode, employs composite plates consisting of a plate of the crude and a plate of the refined metal bolted together and so placed that the pure serves as the cathode of each intermediate composite plate, and the crude as the anode. There is thus no risk of removing a plate of metal, supposed to be refined, to which a portion of the crude is still attached, as the separation between the two is mechanically precise. The method is quite new, and is in use in only one factory at present, the capacity of which is 4,200 tons per year, all of which, however, is not worked by the Stalmann system, but partly by the multiple method. Should experience show that no unforeseen difficulties arise from the substitution of either of these arrangements for the well-tried multiple, the further adoption of one or other of them is probable, for they all present the advantage of needing no external connections for the intermediate plates, and the first two dispense with the use of a separate sheet of pure copper for the cathode, and thus save a certain appreciable amount of capital being locked up. As for the claims that more copper can be refined per horse-power, that less copper is idle and so forth, they are of course quite untenable. It is, as Mr. Badt rightly reiterates, theoretically possible to refine an infinite quantity of copper with a finite expenditure of energy; but full advantage can never be taken of this fact, as it also involves the handling of an infinite quantity of copper, the interest upon the money value of which would be quite a considerable item. In fact, economy of power and restriction of the stock of copper lying idle are incompatible with each other, and local circumstances must always determine which of the two is to be aimed at. Where power is cheap, efficiency in its expenditure can be sacrificed to compactness of plant and rapidity of turnover; where it is dear, efficiency must be studied even at the expense of holding a large stock of copper, a metal prone to market fluctuations.



The circulation of the electrolyte is generally effected in this country by the cascade system, but in America a plan, said to be preferable, is in use, consisting in having a trough run from end to end of the refinery, and each tank supplied therefrom by means of an indiarubber pipe. There is also an alternative to the overhead tank, fed by pumps or an injector, with which we are here familiar, avoiding the trouble caused by the former, and the dilution produced by the condensation of the steam from the latter. In this two collecting tanks are used, and as soon as one is full it is closed air-tight, and air driven in it by a small compressor worked by an electric motor until a pressure of about 25lb. is obtained, sufficing to drive

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the solution up into the troughs, the other tank receiving the overflow. With Smith's arrangement of electrodes it is claimed that no circulation is required, as the free acid from the horizontal surface of each cathode rises through the screen to the anode surface next above it, and acts uniformly thereon. A curious convention obtains in the American copper refining trade anent the purchase of matte at a price influenced by its contents of silver. When the amount of silver is below 30 ounces per ton the price is not raised, but an increment in accordance with the total amount of silver is made when this limit is passed. Consequently copper refiners naturally prefer to buy matte containing rather less than 30 ounces of silver per ton.

The following estimate of the cost of a refinery for an output of 1,000,000lb. of copper per month will be found interesting :—

Building	$30,000
Pavement (asphalte)	2,000
Pipes for steam heating	4,000
Vats	6,000
Lead for lining vats, collecting troughs and tanks	28,000
Lead burning	1,500
Copper conductors	11,000
Rails for overhead blocks for handling plates	2,000
Sulphate of copper	3,500
Sulphuric acid	1,000
Steam injector or pump, or air compressors	1,000
Electric generators, switchboard, instruments	30,000
Shafting and belting	3,000
Total	$123,000

It will be seen that this estimate assumes that water-power will be used for driving the dynamos. In the event of steam-power being required another $20,000 must be added for the cost of engines and boilers. Labour, but not freight, is included in the figures given above. The further amount of capital represented by the copper under treatment is about $80,000, though this will be greater where power is dear, for the reasons already detailed. The total outlay is, therefore, $223,000—that is about £45,000—a capital sufficiently large to show that the setting up of a modern electrolytic copper refinery is an undertaking of some magnitude, unless indeed the copper be obtained merely as a bye-product of some larger industry.

A METHOD OF TESTING THE EFFICIENCY OF TRANSFORMERS.

BY W. E. SUMPNER, D.SC.

The ordinary methods of testing the efficiency of transformers are subject to the defect that the quantity measured is only arrived at by an indirect process, by comparing the values of the input and output of the converter; and as these values are difficult to measure accurately, and are of very nearly equal magnitude, any determination of their ratio is subject to considerable error unless very careful observations are made. In Dr. Hopkinson's recent tests of two Westinghouse transformers, an account of which has just been published in *The Electrician*, this difficulty has been avoided by making the measurements in such a way that the *losses* occurring in the transformers are, as far as possible, measured directly; and the efficiency is deduced by comparing these losses with the output. If W is the load of the transformer in watts, and if w is the waste in watts occurring in the transformer at this load, the efficiency η of the transformer at this load is, of course,

$$\text{efficiency} = \eta = 1 - \frac{w}{W};$$

and, as the efficiency of transformers is something like 95 per cent., the ratio of w to W is only about 1 to 20, so that an error of 1 per cent. in measuring either of these quantities only affects the efficiency η to one-twentieth part of 1 per cent. If, however, the two quantities we measure directly are the input W, and the output W—w, an error of 1 per cent in determining either of these quantities will make an error in η, which is of the same magnitude. As is well known, Dr. Hopkinson has made use of this principle with marked success in testing the combined efficiency of a dynamo and motor; and in the transformer tests just published the chief object has been to determine the losses w as directly as possible. But although the method used by Dr. Hopkinson in these alternate-current tests has yielded excellent results, it is far too complicated for common use, and it may be profitable to inquire whether a simpler method exists.

The distinguishing feature of Dr. Hopkinson's dynamo method is to couple a dynamo and motor together, to supply energy to one, by which it is transferred to the second, which returns it again to the source. The balance of energy supplied by the source is thus no more than the waste of energy which takes place in the double transformation, and a measurement of this amount of energy at once gives the quantity w. Now can we arrange two transformers in such a way that the energy taken by the first from the distributing mains is transferred to the second, and from this back to the mains again? In order to answer this question we must consider the various ways of coupling two transformers together. Since we may connect the primaries in parallel or in series, and are also at liberty to couple the secondaries in either of these ways, we have altogether four cases to consider, which are represented in Figs. 1 to 4.

In the first place, let us take the case of Fig. 1, in which the primaries c_1 c_2 are in parallel, and the secondaries C_1 C_2 in series, a non-inductive resistance being inserted either at R or r for the purpose of regulating the currents. It is easy to see that this arrangement is useless for our present purpose,

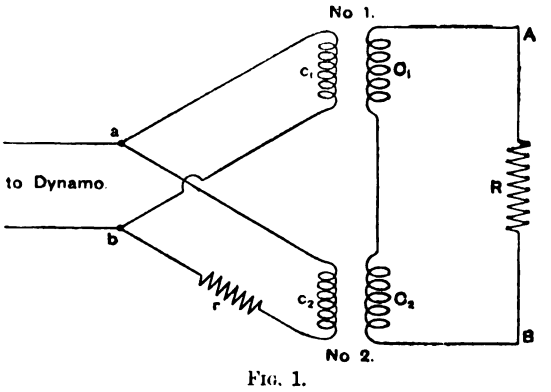

FIG. 1.

as the energy, instead of circulating through the transformers back to the mains, is spent in the non-inductive resistances. Suppose, for definiteness, that the mains a b supply at 100 volts, and that the transformers are each intended to convert a maximum load of 4,000 watts from 100 volts to 2,000 volts. Then, when the full-load currents are flowing through the transformer, it will be seen that 8,000 watts will be expended in heating either R or r. In the former case (r cut out) the potential between the points A and B will be 4,000 volts, and the current 2 amperes; and in the latter case (R being cut out) the potential on the resistance r will be 200 volts and the current 40 amperes. It is true that we can with safety cut out of circuit both r and R, provided we sufficiently lower the voltage on the supply mains a b; and if we arrange this voltage so that the currents in the transformer are the full-load currents, the energy supplied by the mains is all wasted in the transformers. But this waste is not the actual loss occurring in the transformers under the normal full-load conditions. The currents in the coils, and thus the waste in the copper, are no doubt the same; but the iron core is subjected to a very much smaller induction than under ordinary working conditions, so that the iron losses will be very different from those which actually occur in practice. In fact, the voltage induced in this secondary circuit, instead of being 4,000 volts, is merely that necessary to drive the secondary current (2 amperes) through the resistance (15 to 20 ohms) of the two secondary coils.

Let us therefore proceed to the next case, illustrated in Fig. 2, in which both primaries and secondaries are in parallel. If the transformers are exactly alike nothing will happen in consequence of completing the secondary circuit, as the secondary

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voltages exactly neutralise each other. Inserting a resistance at R will not alter this state of things, since no current flows in the secondaries. Putting a resistance in at r will produce a slight change in consequence of the magnetising current taken by the primary c_2. This current will be diminished, and, in order to keep up the voltage on the transformer terminals, a current will flow in the secondary circuit, which will act as a load current as far as transformer No. 1 is concerned, but will act as a magnetising current with regard to transformer No. 2. Altering r will thus only alter the proportion of the excitation of the core caused by the currents in the coils c_2 C_2. Suppose, however, that the two transformers are not exactly alike, and that transformer No. 1 converts from 100 to 2,100 volts, while transformer No. 2 only converts from 100 to 2,000 volts; then there will be a balance of 100 volts available for driving a current round the secondary circuit considered merely as a non-inductive resistance, and if we insert a resistance in either the primary or secondary circuit we can, by adjusting the amount of this, regulate the currents to be what we please. Suppose we choose to insert the resistance in the secondary circuit, then, by adjusting R, we can make the current in the secondary equal to 2 amperes, the full load current. Taking the resistance of each of the secondaries to be 10 ohms, it will be seen that in the case considered 40 volts will be absorbed in the coils, and 60 volts will be left for the resistance R. As a matter of fact, less than this will be absorbed by R, owing to the drop in the transformers due to

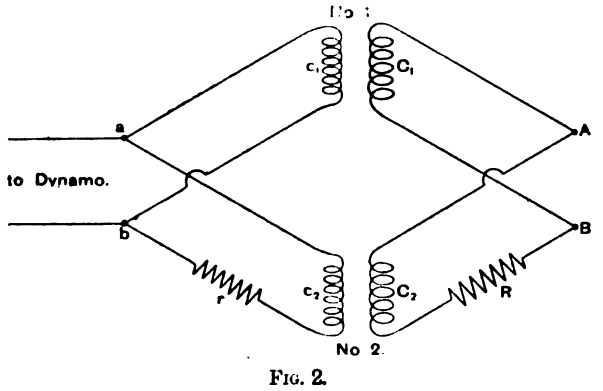

FIG. 2.

magnetic leakage, and the resistance of the primaries; but assuming 60 volts to be the actual potential on R, the resistance of R will be 30 ohms, and only 120 watts will be absorbed. But each of the transformers is now working at full load, and 4,000 watts are being transferred from the mains to the secondary circuit, across transformer No. 1, and, with the exception of the losses in the converters, from the secondary circuit to the mains again across transformer No. 2. The actual energy taken from the mains thus only corresponds with the losses in the transformers, together with the losses occurring in the resistance R. Supposing the transformers have an efficiency of about 95 per cent. the losses occurring in them at full load will amount to about 400 watts, so that the power taken from the mains will be 520 watts, to supply these losses, as well as the waste of 120 watts in the non-inductive resistance. Whether it is more convenient to insert the non-inductive resistance in the low volt or in the high volt circuit, and whether it is preferable to use the fine-wire coils of the converters in the positions C_1 C_2, or in the positions c_1 c_2, will entirely depend upon the means available for testing. But, in any case, it will be easy to measure, with ordinary workshop instruments, the power supplied by the mains, and also that wasted in the non-inductive resistance, with a fair degree of accuracy. The loss of power in the transformers, which we have denoted by w, can thus be measured almost directly, and the load W is given with quite sufficient accuracy by multiplying together the voltage and current of any one coil of the transformers. Even if an error of 5 per cent. is made in estimating both w and W, the efficiency found will not differ from the true value by any appreciable amount. The efficiency of the double conversion is

$$1 - \frac{w}{W},$$

and the efficiency of each transformer is, therefore, the square root of this quantity. As the ratio of w : W is small, not more than 1 : 20 corresponding with a transformer efficiency of 95 per cent., the value of the efficiency η is given quite accurately enough by the formula

$$\eta = 1 - \tfrac{1}{2}\frac{w}{W} - \tfrac{1}{8}\frac{w^2}{W^2},$$

and an error of 10 per cent. in estimating the ratio of w/W does not alter the value of η by more than one quarter per cent. The method just described should, therefore, prove economical, simple, convenient, and accurate. It is at once applicable to any two transformers, which, when placed across the same mains, yield voltages on their secondaries, differing at full load by at least twice the drop of the secondary voltage of either transformer as its load is increased from nothing to its full value. Unfortunately, for this method two transformers of the same type made in the same works, will not differ by as much as this; and in order to apply the method in the case of two exactly similar transformers it is thus necessary to devise some means of supplying energy to the secondary circuit formed by placing the two secondaries in parallel.

A very simple way of doing this appears to be to provide a small additional transformer, whose output at full load is about equal to the waste of power occurring in the two large transformers at full load. If the primary of this small transformer be connected in series with an adjustable resistance x, across the supply mains indicated at the left of Fig. 2, and, if the secondary of this transformer be placed in series with either

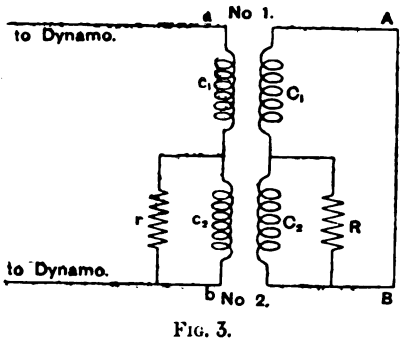

FIG. 3.

the coil C_2 or the coil c_2, in place of the former resistances R, r, respectively, the energy supplied by this secondary, which can be regulated by altering x, will generate any desired current in the big transformers. It will not be necessary to measure the losses in, or to know the efficiency of, the small transformer. In fact, the goodness or badness of this little transformer is a matter of indifference. All that need be done is to measure the losses in, or to know the efficiency of, the small transformer. All that need be done is to measure the *output* of the small secondary, together with the amount of energy taken from the mains by the two large transformers whose primaries are connected with the points a b. The sum of these two quantities will at once give the loss of power, w, in the large transformers, and the output W can of course be measured as easily as before. This modification of the method is in fact preferable to the one already described, not only because it is more economical, but because the quantity w is estimated by adding two measured quantities, and not, as before, by subtracting them. On this account w can be determined with greater accuracy. The particulars of the small transformer can be at once deduced from the primary volts, the amount of waste in the transformers, and the current in the circuit in which the secondary is placed. In the case we have considered, of two 4,000-watt transformers converting from 100 to 2,000 volts, and each absorbing about 200 watts at full load, the full load of the small transformers need not exceed 400 watts. If low potential mains are used for testing, the primary should take 4 amperes at 100 volts, and the secondary should either take 40 amperes at 10 volts, or 2 amperes at 200 volts, according as it is to be used in the low-volt or high-volt circuit. If high-potential mains are used the corresponding details can as easily be found.

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As part of the energy used up in the large transformer is supplied direct from the mains, the full output of the small transformer need not, however, be as much as 400 watts. It is of some interest to see what determines the amount of energy supplied direct from the mains, as compared with that given out by the secondary of the small transformer when placed, say, in the secondary circuit C_1 C_2. This relation depends on the characteristic curves of the two large transformers. If V is the potential of either of the secondaries C_1 C_2 when on open circuit, the voltage of these coils when a current A is flowing through them is $V - v_1$ for the coil C_1, and $V + v_2$ for the coil c_2. The voltage supplied by the small transformer will be $v_1 + v_2$, and the power put in will equal $A(v_1 + v_2)$. Now, $v_1 + v_2$ will increase a little more rapidly than A, so that the power supplied by the small transformer will increase a little faster than the square of the current, and will be, approximately, equal to the losses occurring in the copper of the large transformer. On the other hand, the current taken from the mains will be the difference of the currents in the coils c_1 and c_2, and will be nearly constant for all loads. The power taken from the constant potential mains is thus nearly constant, and approximately represents the losses occurring in the iron of the transformer. If the iron losses are about equal to the copper losses, the small transformer, in the case we have considered, need only have an output of 200 watts.

Having now examined the parallel arrangements of the primaries indicated in Figs. 1 and 2, we may next consider the result of connecting the two primaries in *series*, as indicated in Figs. 3 and 4. It will, however, be unnecessary to consider

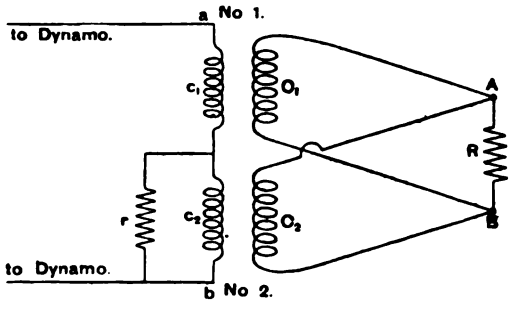

FIG. 4.

these methods at great length, as investigation soon shows that they are only suitable for transformers intended to regulate for a supply of energy on constant-current mains. Prof. Ayrton, in conjunction with the present writer, pointed out more than a year ago that to any electrical method of measurement an analogous method can be found in which amperes are measured instead of volts, and volts are measured instead of amperes. In fact, if the description of any method is taken, and wherever a word occurs denoting current, the word "voltage" is substituted, and *vice versâ*, the result will be the description of a different method analogous to the former. Parallel arrangements convert into series ones, and series arrangements into parallel. Applying this process we at once convert Fig. 2 into Fig. 3 and Fig. 1 into Fig. 4. Just as in Fig. 1, we must not short-circuit the resistance R (or r) if constant potential is maintained between $a\,b$, so in Fig. 4 we must not open-circuit the resistance R (or r) if constant current is supplied by the mains. In the former case we should cause dangerously large currents to flow through the coils; and in the latter the voltages taken by the coils would become excessive. Also, just as the arrangement of Fig. 1 was found unsuitable for our present purpose, because the energy transferred by constant potential transformers was all absorbed in the added resistance, so it will be found that constant-current transformers cannot be well tested by the arrangement shown in Fig. 4, for exactly the same reason. In the same way, all the remarks made above with reference to the apparatus denoted by Fig. 2 can be at once translated to apply to Fig. 3. If the transformers are exactly equal there is no potential available to send a current through the resistance R, and altering r will only alter the state of induction of the core of the transformer to which it is shunted. If the change ratio for currents differs for the two transformers, the non-inductive resistance will absorb the difference of the currents, and by altering its amount the potentials of the transformer terminals can be made to rise to their full load values. One transformer will work the other, and the transformer losses can be measured in an exactly analogous manner to that already described. Also, to apply the method to two transformers which are exactly alike, it will be necessary to use a small transformer, whose full load is about equal to the loss of energy in the large transformers at full load. This small transformer must have its primary placed, not in parallel, but in series with the primaries of the two large transformers; and the secondary must be placed, not in series, but in parallel with either the primary or secondary coil of one of the transformers. In fact, as before, it must replace either r or R.

TEST OF TWO 6,500-WATT WESTINGHOUSE TRANSFORMERS.*

(*Concluded from page 200.*)

If the transformers had been exactly equal, the potentials for the two given by Table I. would have been equal, though they would have differed a little in phase owing to the lines of magnetic induction which pass through the non-magnetic space between the two coils of the transformer.† The difference shows that No. 1 transformer has a ratio of transformation slightly greater than No. 2. If we correct the potential of either No. 1

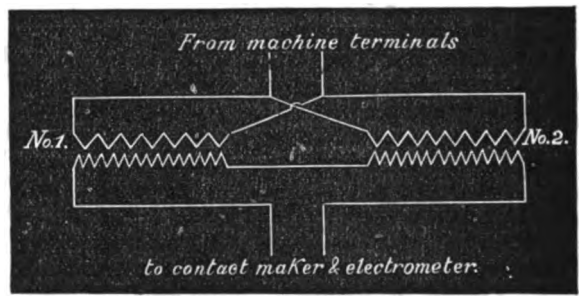

FIG. 8.

or No. 2, there still remains a difference between them, but this difference will be greatest about when the potentials are *nil*. This is due to the lost induction just referred to. In order to check the conclusion that the two transformers are not precisely equal, they were directly compared as in Fig. 8. The transformers were coupled parallel as in Fig. 8, and the difference of potential of the two high-potential coils was measured, the value of its square root of mean square was 12·5 volts, the potential of the transformer being 2,400. This does not necessarily imply that the potentials of the two transformers differ by one-half per cent., it may be largely due to a difference of phase between the two.

The current supplied to the No. 1 transformer is to be accounted for by the currents necessary to magnetise the two transformers, and by the local currents in their cores. To ascertain the former, the curve of magnetisation of one of the transformers was determined by the ballistic galvanometer for nearly the same induction as in Table I. The changes of current supplied by a battery being made by a reversing switch, or by suddenly introducing resistance into the primary circuit, and the consequent changes of induction being measured by the galvanometer. The tardiness of change of current in the transformer due to its self-induction was sufficiently reduced by using many cells and a considerable resistance. The results are shown in Curve V. for a single transformer. In this curve, the abscissæ are the currents in the thin coil of the trans-

* A Report made by Dr. John Hopkinson to the Westinghouse Electric Company.

† Prof. Perry has already pointed out that the effect of such induction cannot be entirely neglected, even in endless circuit transformers.

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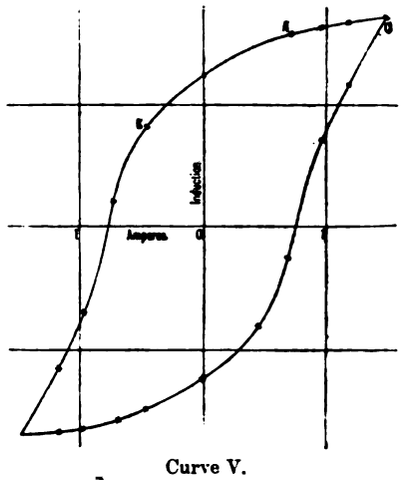
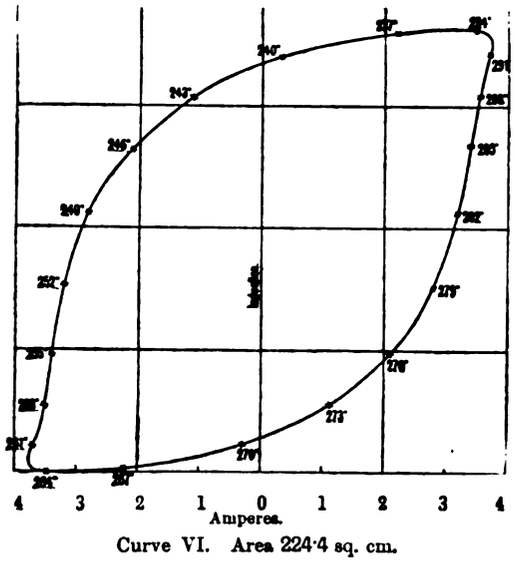
former, divided by 24, to reduce it to the same effect as it would have had if it had been in the thick coil. The ordinates are the inductions as measured by the kick on the galvanometer, but reduced to a scale to make them directly comparable with the volts when the transformer is used with an alternating current. These results are not given in absolute units. The procedure to determine points on the curve was, first, pass the maximum current corresponding to the point C, next suddenly diminish the current by inserting suitable resistance in the thin-coil circuit, and observe the kick, the drop of ordinate from C to A corresponds to the kick, and the abscissa of A is the current after it has been reduced. Next reverse the current, and observe the kick, the kick corresponds to the further drop



Curve V.

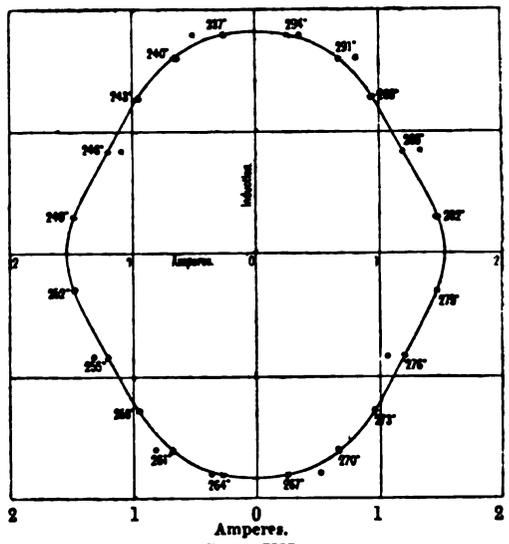
of ordinates from A to B. In this manner a series of points are determined on the curve. Curve VI. shows the relation between induction and magnetising current for the pair of transformers as deduced from the experiments with alternating currents, set forth in Table I. The ordinates in this curve are the area of the curve of potentials of Curve I., for the ordinates of this latter curve are the rates at which the induction is changing, whilst the abscissæ are the currents in the thick wire at corre-



Curve VI. Area 224·4 sq. cm.

sponding times. The points marked ● in Curve VII. give the remainder after deducting the magnetising current as estimates in Curve V., from the currents of Curve VI., that is to say, Curve V. is corrected first for the small difference in maximum induction; then corresponding to any induction the current is taken from the curve, it is doubled as there is only one transformer, and the result is deduced from the corresponding current of Curve VI. The differences are, the magnetising current equivalent and opposite in effect to the local currents in the cores. If the local currents were equivalent to a current in a single secondary circuit, the points ● of Curve VII. ought to have had the form of the full line of Curve VII. drawn through the points +, in which the abscissæ are proportional to the potential difference, and the ordinates to the induction. Returning to Table I., we find that the fall of potential difference on open circuit in the whole combination is 0·8 volt, and that the loss of power in magnetising the cores and in local currents is 222·86 watts, that is a loss for each transformer of 114·13 watts. The total loss of 228 watts may be divided into 126 watts accounted for by hysteresis, and 102 watts due to local currents.

Referring now to Table III. and Curve III. the earlier columns explain themselves, but a word is necessary about the last six columns. The watts supplied to No. 1 are simply the products at each time of the volts at its terminals, and the amperes, passing through, similarly to the watts given out by No. 2. We see firstly that the efficiency of the whole combination with this load is 93·73 per cent., and hence the efficiency of one transformer, if the losses in the two are equal, may be taken as 96·9 per cent. The fall of potential in the whole combination is 6·1 volts; but the fall with no load is 0·8 volt, hence the variation due to the load with constant potential on the thin coil of No. 1 is 5·3 volts, or if the fall of potential in the two transformers were equal, which it is not, for a single transformer, 2·65 volts. Assuming that the transformers are equal, the power lost in resistance would be expected to be the mean of mean current × the difference of potential difference or 215·4 watts. It is, in fact, 150 watts as given by multiplying



Curve VII.

the square of currents by resistances. But the transformers are not exactly equal, and there is the waste magnetic field, both of which will have a small effect on the distribution of loss between the two classes of loss, viz., that by hysteresis, and local currents, and that by resistance, but none upon the gross efficiency.

The other Tables II. and IV. are arranged in exactly the same way as Table III., but the number of observations on Table IV. is insufficient to bring out all the peculiarities of the transformer.

It has already been stated that, if the loss of potential due to load in the two transformers be equal, it will amount to 2·65 per cent. The following experiment was tried to ascertain if this loss was equal:—The transformers were coupled in series as before. The mean potential difference of the thick wire was measured by Thomson's multicellular, and of the thin wire by Thomson's electrostatic voltmeter. The mean of a considerable number of experiments is given in the following table, the load being the same as in Table III., and the results being corrected to the same potential of the thin wire:—

Number.	Full load.		Open circuit.	
	Thomson's multicellular.	Thomson's electrostatic.	Thomson's multicellular.	Thomson's electrostatic.
1	2,380	99·8	2,380	97·0
2	2,380	94·2	2,380	96·2

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This shows that, of a total drop of 4·8 volts, 2·8 volts occurred in No. 1, and 2 volts in No. 2. There is no doubt of the fact that the drop is greater in No. 1 than in No. 2, which is connected with the waste field between the two coils. Of course these transformers are intended to work exactly as No. 2 is working, in which case the drop from no load to nearly full load, as shown by this experiment, is 2·0 volts. The way in which this waste field causes inequality of drop of potential in the two transformers, coupled as in my experiments, is well worthy of careful consideration. The waste field is proportional to the current in the transformers, or, better, to the mean of the two currents in ampere turns. The electromotive force due to this waste field will be proportional to the rate of change of the current. If the current were expressed by a simple harmonic curve, the electromotive force due to the waste field would also be a simple harmonic curve differing in phase by $\frac{N}{2}$. The curve of potentials is roughly in the same phase as the curve of current. Let A be the amplitude of potential difference of No. 2 transformer, B be the amplitude of difference of potential difference in No. 2, or the potential difference of the thin wire divided by 24. $2b$ will be very nearly the amplitude of difference of potential difference between the thick wires of Nos. 1 and 2. The ratios of potentials in No. 1 and No. 2 will then be $\frac{\sqrt{a^2+-4b^2}}{\sqrt{a^2+b^2}}$ and $\frac{\sqrt{a^2+b^2}}{a}$, or $1+\frac{3b^2}{2a^2}$ and $1+\frac{b^2}{2a^2}$, or the drop in the first from this cause is three times as great as in the second transformer. We shall return to the waste field immediately. Putting aside harmonic curves, and returning to the facts as they are, the following Table V. gives first, half the difference of potential difference taken from Table III. that is at each instant the drop of potential in No. 2, secondly the volts of the thin wire of No. 2 reduced for number of convolutions, this is of course the mean of potential difference between 1 and 2, lastly the squares of these volts. From this we see a mean square 100·8 showing the drop in No. 2 to be 2·6 volts, out of a total drop of 6·1, and the remainder 2·5, the drop in No. 1. Diminishing these results by 0·4, the half of 0·8, the fall observed with no load, the actual losses from no load to nearly full load will be 2·2 and 3·1.

Table V.

Half difference of potential difference.	Volts of high potential coil divided by 24.	Squares of volts.
15·6	−5·0	25·0
14·8	41·3	1706 0
11·3	74·3	5520·0
10·8	102 6	10530·0
11·1	131·3	17240 0
5·5	147·1	21640·0
−1·1	137·0	18770·0
−3·1	119·3	14230 0
−5·9	95·1	9040 0
−12·1	53·4	2850 0

Square root of mean square = 100·8.

Turn now to the last column of Table III. This gives the difference of potential differences corrected for the loss of volts by resistance. It is shown on the dotted Curve III.; this curve presents one or two peculiar features. It should be possible to infer the form of this curve from the curve of current. The rates at which the mean current is changing are as follows :—

268½.. 271½...274½...277½ ..280½...283½... 286½... 289½... 292½... —
30·7 ...24·2 ...19·2 ...18·5 ...13·9 ... 1·7 ... − 9·3... − 12·7... − 21·7... − 28·1

which happens to come to a scale which can be at once plotted. The points marked ● are the points of the curve corresponding with the above rates. The agreement of the points with the curve is remarkably close. This exhibits very completely the effect of waste magnetic field in this transformer.

For half power, as taken from Table II., the rates are as follows :—

268½...271½...274½...277½...280½... 283½... 286½... 289½... 292½ ... 295½
14·6 .. 11·5 ... 9·4 ...10·6 .. 4·4 ... − 4·6... − 7·2... − 7·5... − 13·6... − 17·6

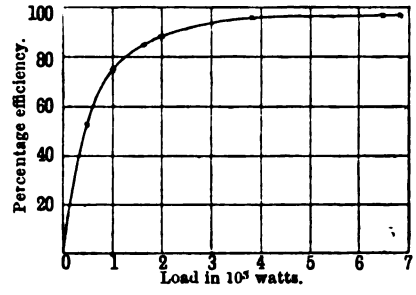
and in the same way in Curve II. the dotted curve represents the difference of electromotive force corrected for resistance, and the points correspond with the above rates.

Curve VIII. gives the efficiencies in terms of the load. This curve is the hyperbole :—

$$\text{Efficiency} = 100.\ \frac{X-(A+BXCX^2)}{X}.$$

Where A = 228, the loss by hysteresis.
B = 0·005, and mainly depends upon the waste field.
C = 0·0000035, and is mainly the loss by resistance.
X = Load in watts.

To sum up, I find that the efficiency of the transformer at full load would be 96·9 per cent.; at half load, 96 per cent.



Curve VIII.

and at quarter load, 84·7 per cent. The magnetising current of the transformer amounts to 114 watts, or 1·75 per cent. The drop of potential from no load to full load is between 2 per cent. and 2·2 per cent.

In conclusion I wish to express my thanks to Mr. Wilson, of King's College; this gentleman carried out the experiments under my direction, and made nearly all the numerical calculations and drew most of the curves for me.

ELECTRIC TRACTION, THE CITY AND SOUTH LONDON ELECTRIC RAILWAY.

BY G. A. GRINDLE.

The use of electrical energy to actuate motors for producing mechanical motion followed closely on the introduction of electro-magnets. The first who seriously applied it to traction purposes appears to have been a Scotchman named Davidson, who, during the years 1837 to 1839, constructed and worked a so-called locomotive capable of carrying two persons. The source of power was a primary battery, and as may be imagined, the motor—or rather motors—were of a very crude description. But the idea was no more than a mere toy, as the car measured 16ft. by 6ft., and the total weight some five tons, while a speed of four miles an hour is said to have been attained. From this time there were many and varied attempts to solve the problem; but the want of a reliable and reasonable source whence to obtain the necessary current militated greatly against any good results; and we may, therefore, pass over the period that elapsed, noting the invention of the Paccinotti machine in 1861, and the subsequent Gramme machine ten years later, till the Vienna Exhibition of 1873, when the first practical and serious demonstration of electricity as a motive power was exhibited,—a Gramme dynamo driven by steam engine, transmitting the current to a similar Gramme machine at a distance of nearly half-a-mile, and from which power was taken to work a pump. Subsequent to this the application of electricity as a producer of motive power progressed but slowly till the summer of 1879, when a small experimental railway was laid down at an Exhibition in Germany. The successful result of this small line clearly foreshadowed what could be done in this direction; and in 1881 an electrical line was permanently laid down for passenger traffic in Berlin, and continues in operation at the present date. In both the latter instances the electric current was gathered from the conductor as the car advanced; but at the close of 1881 the rapid development of storage batteries or accumulators gave fresh impetus to traction work, especially self-contained cars; and many and various experiments and demonstrations have followed, which are of sufficiently recent date to call for no special reference. The bulk, however, of these schemes and experiments has dealt only with light work, such as running of tram cars, and very little until quite recently has been done in what may be termed heavy work, that is to say, running of heavy trains and at considerable speeds. The first step in this direction was the Portrush, Bushmill's, and Giant's Causeway Tramway in the North of Ireland, which was opened in 1883.

* Paper read before the Tramways Institute of Great Britain and Ireland, Tuesday, June 28.

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This line, when originally opened, was some 6¼ miles in length, and has since been extended an additional two miles. The line runs along the roadside with many very severe curves and gradients, and has a 3ft. gauge. The current is generated by water power, and conveyed to the motor by a rail erected at a slight elevation along one side of the track. The equipment consists of motor cars, but the loads carried are not of very great weight. Steam power traction is also employed in the working of the line, which makes it somewhat difficult to arrive at the actual result and cost of the electrical working.

Following in this came the Bessbrook and Newry tramway, which may be regarded as the first serious attempt to deal with heavy goods, mineral, and passenger traffic. This line was opened for traffic in October, 1885, and, in addition to passenger traffic, has to deal with a heavy goods traffic. The line is a little over three miles in length, running from the Great Northern terminus at Newry to Bessbrook, and is built on private property. The gauge is 3ft., while the gradients average 1 in 80, with a maximum of 1 in 50. The line has practically a steady rise in one direction, against which the motor has to draw a load of 18 tons, plus the weight of car and passengers at the speed of six miles an hour, or a load of 12 tons at nine miles an hour. The power for working the generating dynamos is obtained from turbines at a spot about midway along the line; and the current is conveyed to the motors through a steel conductor laid midway between the main rails. Two motor cars, carried on four 6ft. wheel-based bogies, form the locomotive equipment each car carrying 34 passengers, and weighing 8½ tons, without passengers, and equipped with an Edison-Hopkinson dynamo motor of a normal output of 20 H.P., but which power in practice is often exceeded. The electric generating plant consists of two Edison-Hopkinson dynamos, capable of developing about 25 H.P. each. One only is used at a time, and is found to be amply sufficient for the work required. The designing of the plant and equipment of the line was carried out by Messrs. Mather and Platt, of Manchester, to the plans and under the superintendence of Dr. Edward Hopkinson.

The conditions under which this line was constructed were fairly onerous. An outline of them was published in the "*Proceedings* of the Institution of Civil Engineers," from which I make the following extract:—"The Company agreed to place the line entirely at the disposal of the author for a period of a time, and to purchase the electrical plant at a fixed sum when the above conditions had been complied with, and it had been shown that the cost of working, as evidenced by six months' trial, did not exceed the cost of steam traction on a similar line. The work was commenced in November, 1884, and the line opened for traffic in October, 1885, and was formally taken over by the Company, as having fulfilled the conditions of the contract in the following April. Since that time it has been in regular daily operation. Considerable credit is due to the constructors for the way in which the matter was faced, the risks incurred, and the initiative made in this heavy class of work."

Following on this comes the subject of the present Paper and a short history here may not be out of place. In 1884 an application was made to Parliament for powers to construct an underground line from the City to the Elephant and Castle, and granted. The want of such an undertaking had long been felt and various schemes had been suggested to afford facilities for communication between the City of Londondon and the densely populated districts on the south side of the river, and relieve the congested traffic over London Bridge, which in 1886, when the railway was commenced, was estimated at 7,000,000 vehicles and 56,000,000 foot passengers per annum. The course taken from the line was from a terminal station adjoining the Monument under the Thames a few yards above London Bridge and beneath the Borough, Blackman-street, and Newington-causeway to the Elephant and Castle, following as nearly as possible the line of roadway, and so avoiding the cost of land purchase and compensations. The work of construction was commenced in 1886; and so gratifying were the results of the operations on this first section, involving as it did the difficulties of tunnelling under the Thames, that the Directors applied to Parliament in 1887 for further powers authorising them to extend the line to Stockwell, making in all a distance of some three and a quarter miles. The route for this extension was from the Elephant and Castle along the Kennington and Clapham-roads, with stations at Kennington, Kennington Oval and Stockwell. The work of the extension proceeded concurrently with a completion with the original section, and for obvious reasons the opening of the first portion was delayed until the completion of the scheme in its entirety from the City to Stockwell. Since the opening of the line to Stockwell further powers have been sought and obtained for an extension to Clapham Common. This extension, however, has not yet been carried out, but will doubtless shortly be commenced, and cannot but prove a valuable addition to the undertaking, Stockwell being (at present at any rate) a poor centre for a terminal station. The system of tunnelling is somewhat novel, and introduced into this country by Mr. J. H. Greathead, M.Inst. C.E., to whom the design of the line is due, and under whose able superintendence the construction works were so successfully carried out. Entirely separate tunnels are employed for the up and down lines, so avoiding all possibility of collision between trains approaching each other in opposite directions. The material used in the construction of the tunnels is cast iron, built up in consecutive rings, each ring being composed of several segments with a key piece. The tunnels are driven by a shield which in form may be described as like a tube some 10ft. or 12ft. long with a bulkhead, the internal diameter of the tube being slightly larger than the external diameter of the iron tunnel. A short length of soil is excavated in front of the shield, which is then driven ahead by means of hydraulic power, and the segmental ring is built up within the shield tube in the resultant gap caused by the forward movement between the bulkhead and last built ring of the tunnel. The diameter of each tonnel is about 10ft., the stations are of brick, and usual construction of arch and invert, and have a diameter of 22ft. The two tunnels run as a rule side by side, excepting under the Thames, where one line is directly above the other. The depth of the tunnels below the surface of the roadway varies from 50 to 70ft., and is consequently below all sewers, gas-pipes, water-pipes, and subways, and causing no disturbance to the surface of the roadway. At such a depth the question of ventilation would appear to be a serious one; but. as a matter of fact, the tunnels are self-ventilating, and no special arrangement or machinery whatever is employed to effect what is generally acknowledged to be a very satisfactory state of the air in the tunnel. This is due chiefly to the employment of separate tunnels for up and down traffic, the trains fit the tunnels almost like pistons, with the result that every train is continually changing the air, pushing, so to speak, a column of air to the station ahead, whence it escapes by means of the lift shafts, and sucking air from the shafts of the station last passed. Of course, at such a depth, steam locomotion would be out of the question, and originally it was proposed to work the line by the means of cable haulage; and, in fact, contracts for such means of running were actually entered into. In the interval, however, that elapsed between the first conception of the undertaking, and the time when its accomplishment was in the near future, the application of electricity to traction purposes had been advancing by leaps and bounds; and with the success attained on the Newry and Bessbrook line (on which the loads dealt with as mentioned before were but little if any less than those it was proposed to run on the South London line) Messrs. Mather and Platt were induced to approach the Directors of the line with a view to obtaining their consideration as to the advisability of employing electricity as their motive power in lieu of cable, and to submit a complete scheme for the purpose, together with proposals for the working. The matter was the subject of long and careful deliberation by the Board of the Company, and was warmly taken up by the Chairman, Mr. Charles Grey Mott, to whose untiring energy and deep interest in the matter a great part of the success of the undertaking is due. The submitted scheme was eventually accepted in its entirety, and a contract entered into in the early part of 1889 for the equipment of the line in accordance with the same. In addition to the actual equipment of the line an offer was also made to work the line for a period of 12 months, or, at the option of the Company, to guarantee the cost of haulage according to a sliding scale dependent upon the train mileage run per annum, commencing at 3·5d. per train mile for the full possible mileage of 384,800 miles per half-year. The trains under the guarantee to consist of locomotive 10 tons, three coaches of 4·25 tons each, and 100 passengers. During the summer of 1889 various experiments were carried out on a short length of the line then completed, by a temporary plant at Great Dover-street Station and two experimental locomotives. The experience gained in these trials was at the same time both unique and valuable, affording an amount of information which had never before been attained, and which proved invaluable in working out many subsequent details. In the meantime the construction of the plant proceeded rapidly. In close proximity to the Stockwell terminus of the line, on a large plot of land which serves as a general depôt, a spacious engine-house, in which the entire current employed in working the line is generated, was erected.

The plant supplied consisted of three generating dynamos of the Edison-Hopkinson type, each having an output of 450 amperes at 500 volts. The machines are compound-wound, with bar armatures, and are about the largest machines of the class that have ever been constructed, the total weight of each machine being over 17 tons. The driving is effected by means of link leather belts 28in. wide, and to increase the grip the belt is led under a jockey pulley. Each dynamo is independently driven by a vertical compound engine, designed and constructed for Messrs. Mather and Platt by Messrs. John Fowler and Co., of Leeds. The high and low pressure cylinders are 17 in. and 27 in. internal diameter respectively, and are both steam jacketed. The stroke is 2ft. 3in., normal running speed 100 revolutions per minute, giving a piston speed of 450ft. per minute. The engines are fitted with automatic expan-

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sion gear on both high and low pressure cylinders, controlled by a high-speed governor driven by ropes directly from pulley on crank shaft. The steam pressure employed is 140lb. per square inch. The fly-wheels are very massive, 14ft. in diameter, 28in wide on face, and weigh 14 tons. Each engine will indicate 375 H.P., and in practice two engines and dynamos are employed, and are amply sufficient to work the entire line, the third engine being kept in reserve. The engines are supplied with steam from six steel boilers of the Lancashire type, 28ft. long, 7ft. diameter, and are fed with fuel by means of Vicars' mechanical stoker. The water supply is effected by means of two Worthington pumps, and before entering boiler is forced through two feed-water heaters, heated by the exhaust steam from engines. Since the opening of the line, and in view of the extension to Clapham Common, a fourth engine and dynamo, similar to the original three, have been erected, also two additional boilers. The boiler-house is below the general ground level, which greatly facilitates the stoking, the fuel being simply tipped straight into the hoppers, and so avoiding all cost for elevating, &c. Adjoining the engine-house is a fitting-shop, where minor repairs can be carried out. From the dynamos the current generated is conveyed by means of lead-covered cables to a massive but simple switchboard, and is there distributed to the feeding mains. These mains or cables, of which there are four, are of the well-known Fowler-Waring manufacture, and consist of a 61/14 B.W.G. copper core, insulated with patent insulating material and lead-sheathed. The cables are carried on brackets along the sides of the tunnel, and led into the various signal-boxes. In the signal-boxes are fixed small slate distributing boards, fitted with plugs and fuses, and from these the current is conveyed to the working conductor by means of feeder cables. The working conductor is of steel, of channel section specially rolled for the purpose, and of such composition as to ensure its having a low specific resistance. It is carried by glass insulators, which are cleated with creosoted blocks to the sleepers, and laid between the two main rails at a distance of about one foot from each rail; this position being rendered necessary on account of the low position of the central buffer coupling. The lengths of conductor are fixed with two small fish-plates and four bolts, as a mechanical coupling, while the electrical connection is ensured by means of a laminated copper strip, secured by four copper rivets. The steel conductor is not continuous, but broken at every station. The intervening gap, a length of some two feet, being made up with a piece of well-seasoned oak, by which means it is possible to isolate any one section of the line without interfering with the remaining sections, or in the case of any accidental failure occurring on any section it automatically disconnects itself from the system. At the points and crossings, which are in every respect similar to ordinary railway practice, the shoes or collectors have to be lifted over the crossing rail, the level of the conductor being one inch below that of the main rails. This is accomplished in a simple and effective method by means of inclined wooden planes, up which the shoes run. The insulation throughout the line is exceptionally high. The daily test of the entire system, which includes generators, switchboards, cables, feeders, working conductor, points and crossings, locomotives, and lighting circuits with the full pressure of 500 volts, does not give a leakage current of one ampere, or considerably less than 1 H.P., and is often as low as one-fourth of an ampere. The conditions of the line naturally are highly favourable in this matter, no difficulty with weather having to be contended with. The return circuit is made by means of the main rails, which are connected in addition to the ordinary fish-plates with copper connecting strips, fixed in the same manner as in the working conductor.

The electric locomotives, of which fourteen were supplied for working the line, were each designed to be capable of exerting a tractive force of 3,000lb., and running at a speed of 25 miles per hour. In general appearance the locomotives closely resemble steam tram motors. The weight of each locomotive is 10 tons, and it is carried on two axles, with a wheel base of 6ft. In the construction of these motors a striking and novel departure from anything that had previously been attempted was made with regard to the armature. Instead of being, as in previous engines, connected with the driving axles by means of gearing belts or chains, the armatures were actually built up on the axles themselves, thus entirely obviating all the necessary incumbent complications that had hitherto been in vogue. The magnets are supported partly by the axles and partly suspended from the car itself, an arrangement which allows of a certain amount of freedom of angular motion round the axle, yet always remaining concentric with the armature. A separate and independent motor is fitted on each axle. The motors are series-wound, and the armature revolution per minute, of course, varies with the speed of the train. At twenty miles per hour the revolutions are approximately 250 per minute. The current is taken from the working conductor by means of three sliding shoes fixed by hinged supports to the frame. The shoes are of cast iron, and it is found in practice that they will run about 10,000 miles before requiring renewal. From the shoes the current is carried by an insulated cable to the main-resistance switch, which controls both motors. The resistances are placed in series with the motors, and gradually cut out as the switch is put over. A second switch controls the reversing movement, which is effected by changing the direction in which the current passes through the armature. The locomotives are fitted with hand and air brakes, the latter being of the well-known Westinghouse type, and continuous throughout the train. To work the air brake a supply of compressed air is carried in two steel reservoirs on the locomotive, and replenished at Stockwell on every round journey. Connection between the locomotive and carriages is effected by means of a central buffer coupling. The trains are made up of three coaches, each constructed to carry 34 passengers, open from end to end, with two longitudinal seats like those in an ordinary tramcar. Entrance into the cars is gained by means of end doors, and between the carriages intermediate platforms are fixed, fitted with collapsible side gates. The carriages, which are 29ft. over all, are carried on two four-wheel trucks, and, exclusive of passengers, weigh over 7 tons each. The lighting is effected by means of incandescent lamps, supplied with current from the working conductor.

The gauge of the line is, standard, 4ft. 8½in., and the rails, 60lb. weight per yard, are of Ebbw Vale steel. The track is not ballasted, the cross sleepers merely resting on the sides of the iron tunnel. The road has many severe curves and gradients, the sharpest curve having a radius of 1½ chains, and the heaviest gradient being 1 in 14 with, and 1 in 25 against, the load. A complete telegraphic and block signalling system is carried throughout the line. Such is a brief description of the line and its equipment, the entire electrical portion of the latter being constructed by Messrs. Mather and Platt, of Manchester, from the designs, and under the superintendence, of Dr. Edward Hopkinson, a partner in the firm.

A few words on the working and results may, perhaps, be of interest. On November 4, 1890, the line was formally inaugurated by his Royal Highness the Prince of Wales, who, accompanied by his late Royal Highness the Duke of Clarence, made the journey from the City to Stockwell, and visited and inspected the plant and works. Shortly after this the line was passed by the Inspectors of the Board of Trade, and eventually opened for public traffic on December 18, 1890.

Upwards of 18 months have therefore elapsed since the public opening, during which time the line has been in daily operation. For the first few months a train service of some twelve trains per hour each way was maintained; but with the growing traffic this has been increased, until at the present time, during the busy hours of the morning and evening, as many as 16 and 17 trains per hour are run. The public appreciation of the line is shown by the increasing numbers of passengers carried. For the half-year ended June 30, 1891, the number of train miles run was 141,408, and passengers carried 2,412,343. For the second half-year ended December 31, 1891, the train mileage run was 188,666 miles, and passengers carried 2,749,055, exclusive of season ticket holders, the revenue from which on the average fare would represent 37,300 additional passengers, or a total of 2,786,355. The revenue receipts and expenditure have been for the first half-year—receipts £19,637, expenditure £15,520, or a balance to the good of £4,117. For the second half-year—receipts £20,243, expenditure £15,516, balance to the good £4,727. These figures are significant when compared with the train mileage and passengers carried, 47,258 train miles more having been run and 374,000 more passengers carried during the second half-year; while the total expenditure has been £4 less, which reflects much credit on both the General Manager and Engineer, Messrs. T. C. Jenkin and Basil Mott, for the manner in which the working of the line has been conducted. It is to be regretted that this meeting was not a few weeks later, when the results of the present half-year would have been available for comparison; but to date since the opening of the line the total mileage run is over half a million miles, and the number of passengers carried upwards of seven millions. The percentage of expenditure to receipts may appear high, but a careful study and analysis of the figures show that this is not abnormally due to the traction expenses—the cost of locomotive and generating power, including salaries, office expenses, general superintendence, running expenses (including wages connected with the working of locomotive and generating engines, coal and coke, gas, water, oil, tallow, and other stores), repairs and renewals including wages and materials—only amounting to 40 per cent. of the total expenditure, or 30 per cent. of the gross receipts, which, I venture to submit, will compare favourably with any other mode of traction. From these figures it will be seen that the cost per train mile for the last half-year was just under 8d., while under the sliding scale before mentioned the cost per train mile on the mileage run would have been 7·125 pence. But in the actual cost of 8d. drivers' wages and other items are included which were excluded in the sliding scale, and, if deducted, bring the actual cost down to 5¼d. per train mile. This, I think, will be generally admitted as highly satisfactory, especially when the serious increase of the train load (no less than 40 per cent. above that originally stipulated for),

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caused by the increased weight of carriage, is taken into consideration—the total train load for the 5¼d. per mile being 42 tons. The working of the plant and line has been both regular and satisfactory.

On no single occasion during the whole period that the line has been in operation has there been any accident or stoppage of the generating dynamos, showing conclusively the security and certainty with which electrical plant can be worked. Slight delays have occurred from time to time with the locomotives; but these have, in almost every instance, been distinctly due and traceable to the unexpected load and strain put upon them, and in spite of which the record of work done by these locomotives will compare favourably with that accomplished by steam locomotives. The average mileage of the locomotives in regular use during the past year has been no less than 27,000 miles, while on a well-equipped steam road the average is 20,000 to 23,000 miles per locomotive. The success of the line is further shown by the numerous similar projects which have followed. Last year a Bill was passed through Parliament authorising the construction of the Central London Railway, a line seven miles in length, extending from the City to Bayswater to be constructed in the same manner, and to be worked electrically on similar principles, but on a much larger scale. During the present Session no less than six Bills have been presented applying for powers to authorise the construction of similar undertakings. Of these six Bills, four of which are applications for new lines, and two for extensions of existing powers (including the extension of the City and South London line to the Angel, Islington) three have passed through both Houses, namely, the Baker-street and Waterloo line, the Great Northern and City line, and an extension to Liverpool-street of the authorised Central London line. The Great Northern and City line running from Drayton Park to Finsbury-pavement is of exceptional interest, being intended to relieve the Great Northern traffic, and over which it is proposed to run the ordinary rolling stock of the Great Northern railway. The above Bills in the first instance were referred to a Joint Committee of both Houses appointed to consider the whole question as to the best method of dealing with the electric and cable railways schemes, and to report their opinion as to whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and probable future traffic. The Joint Committee, after having met on several occasions, and having had submitted to them a large amount of evidence, reported strongly in favour of the various schemes, and with regard to electric traction as follows:—"The Committee report that the evidence submitted to them was conclusively in favour of the sufficiency and special adaptability of electricity as a motive power to the proposed underground tubular railways."

It may, therefore, be assumed that before very long this system of transport will become fairly general in London, affording, as it does, a cheap, rapid, and safe mode of conveyance. On the table is a small model of the Bessbrook and Newry motor car, also a model locomotive of the same power as the City and South London line, and but little more in weight, with Hopkinson's patent double motor, in which a single magnetic circuit embraces both armatures, the motors being carried entirely from the framework, and, therefore, on springs, and driving the axles by diagonal connecting rods, according to a plan devised by the late Mr. Lange, of Messrs. Beyer, Peacock and Co. (Limited). The photographs round the room are various views of the plant, &c., of the Bessbrook and Newry and the City and South London lines.

LONDON CHAMBER OF COMMERCE AND OVERHEAD WIRES.

On Wednesday afternoon last a deputation, consisting of Sir Vincent Barrington, Major Flood Page, and Mr. Henry Edmunds, representing the London Chamber of Commerce, waited on Sir Courtenay Boyle to urge certain objections to the Overhead Wire Byelaws as drafted by the London County Council.*

The deputation was introduced by Sir V. K. Barrington, who said that, as a member of the Council of the London Chamber of Commerce, he ought to mention that the Electrical Trade Section was one of the strongest sections of that body, and it fairly represented the electrical interests of the metropolis. Great anxiety was felt about this matter of overhead wires, and the size of the deputation gave no indication of the interest and importance attached to the subject, since an important Congress of Chambers of Commerce was being held elsewhere, and prevented many from being present. The object of the deputation was to make certain representations on behalf of the Electrical Trade Section of the London Chamber of Commerce with regard to the byelaws regulating overhead wires which had been drawn up by the London County Council. Government departments now paid more attention to trade interests than was formerly the case, and although the interests of the public must of necessity come before those of any section of the community, still he would submit that it was possible at times to push the former to such an extent that the latter were injured without any appreciable benefit to the public at large. He would ask Major Flood Page to deal with the matter in detail.

Sir Courtenay Boyle pointed out that it was a little irregular after a matter had been discussed to hear *ex parte* statements from one side alone, but as, much to his regret, the London Chamber of Commerce had not been represented at the public inquiry previously held, the Board of Trade had, in consideration of the peculiar position occupied by the London Chamber of Commerce, decided to hear them further on the subject.

Major Flood Page then proceeded to deal with the various clauses in detail, and in reply,

Sir Courtenay Boyle announced that the following concessions had been made. In Clause 1, positions of all wires were to be marked by the company owning them, on a map (of a scale of 25 inches to the mile), to be provided by the London County Council. The period of registration was also extended from three to six months. In Clause 2, "not more than one month after," was to be substituted for "not less than 14 days before." In Clause 4, 6ft. was substituted for 7ft. as the minimum height of wires over roofs. It was also decided that some mark indicating the date of erection should be placed on each pole, but not necessarily the date itself; also where wires belonging to several companies were fastened to one pole, the company owning that pole should be deemed responsible for the condition of all the wires attached to it. With regard to the question of access, Sir Courtenay Boyle said he was afraid he should not be able to give the deputation much satisfaction. The question had received the most careful consideration at the hands of the Board of Trade. The clause had been amended so as to require that reasonable notice should be given to the Company that inspection was to be made, but he could not promise more. He had taken care that the views of the London Chamber of Commerce should be put in the strongest possible manner.

Major Flood Page said that the National Telephone service was admittedly bad, indeed, Mr. Forbes himself had acknowledged it, but it was because they had not the powers which Parliament said they ought to have, and they could not put their wires underground. They sent 160,000,000 messages as compared with 6,000,000 sent by the Post Office, and he thought it was absolutely necessary that they should have as free a hand as their partners, the Government, in this matter. It would be almost impossible, he thought, to obtain wayleaves if they had to give security for inspection and entrance by the officers of the Local Authority.

Sir Courtenay Boyle, while not holding out any hope that any further amendment could be made, promised to lay the matter before the President of the Board of Trade.

The deputation then thanked Sir Courtenay Boyle for his courteous reception and the trouble he had taken in the matter, and withdrew.

* See *The Electrician*, December 11, 1891, p. 149.

PRICING GOODS AT THE COLUMBIAN EXPOSITION.

The following extracts from a leading article in last week's *Engineering* form an appropriate supplement to our own brief comments:—

It was obvious from the commencement that there could be no British Section at all unless one point of vital importance was definitely fixed. This point referred to certain privileges being accorded to foreign exhibitors in regard to affixing prices on the goods they would display. At the Centennial Exhibition of 1876 this matter was unaccountably overlooked, and after it was too late to withdraw, foreign exhibitors found themselves compelled to submit to the damaging necessity of increasing the prices attached to their goods by the amount of duties then enforced. On account of this regulation, a great part of the benefit that would otherwise have accrued to foreign exhibitors was lost, and the unfortunate impression which this policy produced has never been effaced. . . . Bearing these things in mind, it was obvious to the Royal Commission that the widest privileges in the matter of pricing exhibits should be assured to manufacturers, in the clearest and most unmistakable manner, before they could be asked to undertake the trouble and expense of forming a British Section at Chicago.

In September last this all-important subject was laid before Mr. Foster, the Secretary of the Treasury, by the English and German Commissioners, the exact wording of the demand being as follows: Exhibitors of goods sold for delivery after the close of the Exhibition should "in all cases be at liberty to mark them for sale at

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such prices as they may think fit, entirely irrespective of all customs dues, such dues being paid to the Treasury agents by the purchaser prior to his removing the goods he has bought, after the close of the Exhibition." In the presence of Mr. Butterworth, the solicitor-general to the Exposition, and of Mr. McCormick, the American representative in England, Mr. Foster assured the Royal and Imperial Commissioners that there could be nothing to prevent foreign exhibitors from marking their goods in the manner desired, that is with the bonded prices. A few days later satisfactory assurances on the subject were given to the Commissioners by Colonel Davis, Director-General of the Exposition in Chicago, and so lately as February last they were formally repeated in correspondence passing between the Royal Commission and Colonel Davis. As soon as this vital point had been settled, the Royal Commission was enabled to approach manufacturers and to give them the assurance that they would be privileged to price their goods exclusive and inclusive of duty. Without such an assurance it is certain that the limited success that has been achieved would have been unattainable. Acting upon the guarantees of the Commission a certain number of manufacturers are preparing to go to Chicago next year, and the recent discovery of a policy intended to nullify the undertakings of Colonel Davis, and to deprive British exhibitors of their only important privilege, has produced a profoundly painful impression, not only among manufacturers, but on all those in England who have the interests of the American Exposition at heart.

It is obvious that this circular had never been communicated to the Royal Commission, because their official handbook for exhibitors, of a much later date, still contains the clause guaranteeing manufacturers the privilege of pricing their goods free of duty. Moreover, had the circular containing this strange departure from the original undertaking been so communicated, the Royal Commission would most certainly have lost no time in informing exhibitors. So limited, indeed, has been the publicity given to this document that it is within our own personal knowledge that some of the most influential men in Chicago connected with the Exhibition were, until very recently, unaware of its existence. Of course it would be wholly improper to pass judgment at present upon this act of the Director-General. The Royal Commission, who recently sent their secretary to Chicago, will undoubtedly give him the most stringent instructions to protect British exhibitors and to maintain the original guarantees intact. But the amplest assurances upon this point will not be sufficient to remove the unfavourable impression from the majority of our manufacturers, who are already unreasonably prejudiced against the commercial and political methods of the United States; and even if this matter is cleared up, many of them will ask what unforeseen dangers still await them.

The "privilege" accorded by Colonel Davis to foreign exhibitors, of affixing the actual cost price of goods is simply absurd; while the alternative of adding duty to the selling price, or of paying the duty themselves, is one which may reasonably determine manufacturers already well disposed to abstain altogether. Under the most favourable circumstances this incident must be regarded as a deplorable one; under very possible conditions it may result in limiting the Columbiam Exposition to a national celebration.

Pending definite explanations and renewed assurances, it may not be out of place to point out here that the circular of Colonel Davis is probably the result of political pressure, combined with the well-known objection of many American manufacturers and merchants to meet European competitors at Chicago next year. Politics are inseparable from all great undertakings in America, and the Columbian Exposition could be no exception to the rule. Republican and Democratic factions have each their grip upon the World's Fair, and while for every reason, excepting possibly that of commercial competition, the latter party would prefer above all things to see foreign goods priced free of duty, the former would resist to the utmost any such privileges being accorded; in fact, the concluding paragraph of Colonel Davis's circular shows clearly how much afraid advanced Protectionists are of allowing the masses in America to know what protection costs them, a lesson which they certainly would learn to some purpose from the low-priced goods in the foreign sections of the Exhibition.

In conclusion, we would point out to intending British exhibitors not to arrive at any hasty conclusion on the subject of the Davis circular, but to await the information that will doubtless be accorded them without delay by the Royal Commission, who is responsible for protecting their interests. At the same time it will not be unreasonable if manufacturers express their opinion on the subject of these restrictive regulations, and express it in no uncertain voice, that shall be heard as far as the City of Chicago.

BOOKS, &c., RECEIVED.

"Elektrizität und Schwerkraft im Lichte einheitlicher Naturanschauung." By Th. Schwartze. (Berlin: A. Seydel.)

"Spons' Engineers' and Contractors' Illustrated Book of Prices." (London: E. and F. N. Spon.) 1892.

LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

In the Court of Appeal on Monday, June 27th, before Lords Justices Lindley, Lopes, and Kay, Mr. St. G. Lane Fox appealed against the decision of Mr. Justice A. L. Smith in the Chancery Division in his case against the Kensington and Knightsbridge Electric Lighting Company. This case was reported in *The Electrician*, Vol. XXVIII., p. 437 *et seq.* The judgment was given in *The Electrician*, Vol. XXVIII., p. 580.

Mr. LANE FOX commenced by apologising for any inconvenience to which he might put the Court by conducting his case in person. He said that it had been remarked that there had been an unexplained delay in bringing the action. He attributed this to two causes. First, the industry was at the time of the patent entirely new. He had been led to study the distribution of electric lighting by some experiments which he had carried out in the lighting of gas-lamps in Pall-mall. There were several entirely new ideas—that of constant pressure was new, and was, indeed, contrary to what was believed possible by the electrical authorities of the day. Another reason for the delay was that there were no workmen at that time, and men had to be educated. He had thus educated a large number of men. One of the important parts of lampmaking was the glass blowing, and glass blowers used to get £4 to £7 per week. There had been a cross action in the case of "Brush *v.* Holland," in which this patent had been brought forward; and in a compromise the Edison Company admitted the validity of the patent, and the Brush Company gave them a licence; but he had not ratified this licence. In beginning the explanation of the scientific part of the case, the plaintiff explained that according to his invention, the conductors or mains ramified all over the district under a constant pressure. He would use the terms "electromotive force," "difference of potential," "pressure," and "voltage" to mean the same thing. Lord Justice Kay remarked, "We have a certain general knowledge, nothing like your own, of course, of incandescent lighting." Variations of pressure were possible for many reasons, and might take place suddenly; he, therefore, thought that a buffer of some sort was desirable. He suggested in his patent that several batteries for this purpose would be desirable. It was inevitable, of course, that the mains should have some resistance, but he had conceived the new idea of a low-resistance main and of high-resistance lamps. He had described in his patent a lamp which was typical of those in use at the present day, having a luminous surface proportioned to the amount of light, and a high resistance. Mr. Lane Fox then discussed the alleged disconformity between the provisional and the complete specification, and the question whether the general claim for the advantages of his invention was set forth in the provisional specification. He said that Mr. Justice A. L. Smith had drawn a distinction between "regulation of pressure" and keeping the pressure constant. It had been alleged that although the regulating device had been struck out by disclaimer, the regulation was retained, and he argued that keeping the pressure constant was the same thing as regulating. Mr. Justice Kay said that there appeared to be two modes of regulation described in the specification; the one by an electrometer, and another by means of a secondary battery, which would supply any deficiency, whether caused by change of speed of the dynamo, or by change in the number of lamps. Mr. Lane Fox called attention to a passage in the judgment (*The Electrician*, Vol. XXVIII., p. 580, three-quarters down the second column), in which Mr. Justice Smith said that "by coupling up secondary batteries to his system of distribution of electric current, he might be able to neutralise the pressure of the mains." Lord Justice Kay thought that this must be a mistake for "equalise," and after a little discussion it appeared to be admitted that this must have been the case, but the original judgment would be examined. He then referred to another passage in the judgment in which the opening speech of the Attorney-General was quoted by the Judge (*The Electrician*, Vol. XXVIII., p. 582, top of second column), where he used the words "absolutely maintained at a constant pressure." Mr. Lane Fox thought that these words of the Attorney-General were too strong, for he could not and never had claimed absolute constancy of pressure, and he thought that Mr. Justice A. L. Smith, when quoting this, had in his mind that he was claiming too much. Line 34, p. 2 of the specification, said that the electromotive force of the conducting mains should be kept as nearly as possible constant. With regard to the alleged disconformity, Mr. Lane Fox said that supposing there was no claim in the provisional specification for the use of secondary batteries, he could not use them for regulating as described in the complete specification, and cited "Nuttall *v.* Hargreaves." Even if a distinction could be drawn between regulation and keeping the pressure constant, this objection could not apply, since he had only amplified the invention in the complete specification. There was nothing in the title to cover the combination which he claimed as his invention, except the word "regulating." In the specification he had said, p. 2, line 48, that it was "necessary to have some regulator." He regretted that the word "necessary" had been used; for further experience had shown that no such regulator as that which was described in the patent, and afterwards cut out by disclaimer, was really necessary. He said that he did not understand what Mr. Justice A. L. Smith had meant by making a difference between regulating and keeping the pressure constant. The three judges held a consultation together for some time at this point; and Lord Justice Lindley then said that the object of this invention was clearly for keeping the pressure constant, and that there were two things described for doing it. The inventor had found by experiment that one of these was not necessary. He now admitted that it was unnecessary, and the use of the word "necessary" in the provisional specification was unfortunate. The question of the use of batteries was then discussed; and Lord Justice Kay said that when you tell a man how to carry out an invention, it does not seem sufficient to state that the size of the batteries should be very large. Lord Justice

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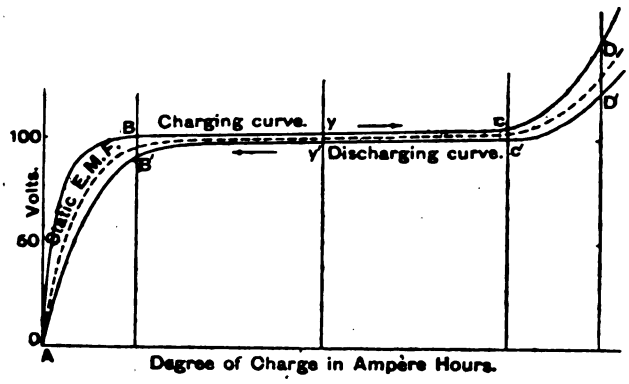
Lindley said that the circumstances of the case would affect this; and Lord Justice Kay asked, Cannot the batteries be too large? Mr. Lane Fox explained that the batteries could not be too large unless owing to the fact that they were too expensive. He then explained that the number of the cells was proportional to the number of the volts, while the capacity was proportional to the surface of the plates, and the cells should have as large a surface as they could afford to give them. He stated the case of the Plimpton roller skates, in which the sufficiency of the size of a part was discussed, and said that if a workman found that the cells were not large enough he would only make them larger. Lord Justice Kay then quoted from the judgment, where it is said near the end, "There is not a suggestion as to size given excepting that there should be a very large conducting surface." The evidence of Prof. Barrett, Prof. Perry, and Sir F. Bramwell, was then discussed by Mr. Lane Fox, who pointed out that this last witness had stated that the expense was a real drawback to making the plates of as large a size as they might be. Passing then to the sufficiency, Mr. Lane Fox cited "Edison *v.* Holland," where a tar putty filament was described by Edison, but no proportions were given. Many attempts by experts had failed to make this putty, and it was obvious that more skill was required to make tar putty filaments without proper instruction than to adjust the size of a battery to produce regulation. He briefly alluded to the use of switches, and then referred to a remarkable statement by Mr. King, which was quoted in the judgment. He said (*The Electrician*, Vol. XXVIII., p. 581, top of second column), "I will swear that there would be more variation, that is in the voltage in the mains with secondary batteries, than without them. I say the secondary batteries; the current remaining constant tends to cause a variation rather than to diminish it." Mr. Lane Fox had no scruples in saying that this was a deliberate mis-statement of fact. He called attention to the fact that the evidence on his side came from scientific men, but that the witnesses on the other side were commercially interested in the matter. He was confronted by two separate lines of argument. First, that the batteries would act as described, but that the defendants used them for storage; and without switches they could not get enough storage. The second statement was based upon this isolated statement of Mr. King that the batteries were of no use for regulation, and that, on the contrary, they would introduce variation where no variation would otherwise have been. He was astounded at this statement, and was amazed at its appearance in the judgment. It was altogether an isolated statement. He asked Mr. Wallace whether he was prepared to withdraw it, but he (Mr. Wallace) declined to do so.

After quoting some of Sir F. Bramwell's evidence Mr. Lane Fox proceeded to explain the Planté battery, and in order to illustrate its action put in a curve. He specially called their lordships' attention to the fact that with large plates and a small current both the



curves approximated to the static curve. The reason why the defendants' batteries behaved otherwise was because they used their batteries for storage when the engines were not running—a purely commercial consideration. Mr. Lane Fox assumed that his invention had not been anticipated, and based this assumption on the last sentence but one in the judgment, which says that:—"It is not necessary to give any further judgment in this case; but had the plaintiff been able to surmount the above-mentioned difficulties, and had established that by his invention he could have brought about what the Attorney-General said he could, my judgment would have been that his invention was the subject matter of a patent, that it had not been anticipated, and that the defendants had infringed it." Mr. Wallace, however, contended that the Judge had meant that the invention would not have been anticipated if he could have brought about by the invention what he said he could.

The Judges consulted together for some time upon this matter. It appeared that when the Attorney-General made that claim, he claimed too much, and on the other hand, it was not quite clear what Mr. Justice A. L. Smith had meant. It was decided that the Judges would consult Lord Justice Smith upon this matter; and Mr. Lane Fox was told he need not assume at present that his patent had been anticipated.

TUESDAY, JUNE 28TH.

Mr. LANE FOX, continuing his address to the Court, said that the regulating effect of the secondary batteries had been alleged to be incidental only. He cited "Edison *v.* Holland" again to show that the "flashing" process described in the Cheeseborough patent was used in the same way. Lord Justice Kay said that it came to this, the defendants said that regulation was only incidental; but whatever importance was attached to it, if they used it they used it. Mr. Lane Fox added that they not only used it, but derived great advantage from it. The utility in this case, he argued, depended on the commercial value of the regulation, and therefore on the degree of regulation, and cited the Plimpton skate case again to show that even a small degree of utility will do. The whole point of the question of utility was whether they could usefully charge a battery at less than 105 volts. He illustrated the point by reference to the mode of supplying oxygen gas compressed into iron bottles. When a considerable quantity of gas was compressed into such a bottle it was said to be "full," and when the gas had been spent and the pressure reduced to that of the atmosphere, it was said to be "empty;" but this was not really the case. After explaining that he did not require the large amount of storage that was used by the defendants, with the necessary large difference of pressure, Lord Justice Lindley said, "Your point is that a small difference of potential will do." Mr. Lane Fox said that it had been alleged that when working with a small difference of potential the batteries would deteriorate, and added that he had prepared rebutting evidence on that point. A discussion on the subject of rebutting evidence then took place, and the Court said that such evidence could only be brought if some new point were raised which had not been referred to during the plaintiff's case. Mr. Lane Fox said that a new point had been raised, about the damage that a battery might sustain if not fully charged. He contended that the battery as described by him was suitable for the purpose of regulation. He then described Planté's use of his battery, and alluded to the "plateau," or period during which a considerable discharge may be put in or taken out without greatly affecting the difference of potential. In reply to a question by Lord Justice Kay, Mr. Lane Fox said that Planté did not require excessive charging, This was only needed in the later developments of the Planté battery. Excessive charging was necessary for the health of pasted cells, but not for Planté, who clearly stated that it was not necessary to go beyond the bubbling point. Injury had been done to a cell in Mr. Crompton's experiments, where 101 volts were used; but until this experiment was described he did not know that stress would be laid upon this. Mr. Wallace, interposing, pointed out that attention had been called to this injury in cross-examination during the first day of the trial. Mr. Lane Fox drew attention to the evidence of Prof. Barrett, who had used cells for six years with no deterioration, but who was only then just charging his cells, because they had had such a wonderful life. Speaking of the difference of pressure allowed by the Board of Trade, Mr. Lane Fox said that a difference of four per cent. up and four per cent. down was allowed from the normal. Mr. Wallace, interposing, assured the Court that it was two per cent. up and two per cent. down; but Mr. Lane Fox held to the figure which he had given. Some discussion arose as to whether the Crompton-Howell batteries were of the Planté type or no, and Mr. Swinburne's evidence was read, in which he said that "I would not say a Crompton-Howell cell was a Planté."

After reading many extracts from the evidence about regulation being incidental to storage, Lord Justice Kay attempted to lead the plaintiff back to the evidence on the effect of charging at small potential difference, on the health of the batteries; but Mr. Lane Fox did not appear to understand what his Lordship wanted. The question then arose as to the need for always charging up to the point B on Prof. Ayrton's curve; and after a long argument, the point appeared to be cleared up that Mr. Lane Fox held that there was no evidence to support the finding of the Judge that this was always necessary. Mr. Lane Fox thought that Prof. Ayrton's curves might be dismissed, since Mr. Crompton in his evidence had said that these curves did not apply to his batteries. The Court put it to Mr. Lane Fox that the defendant said that he must go to 110 volts in order to discharge at 100 volts: but he replied that the defendants used cells for storage with a thick coating of active material. Lord Justice Kay said that the battery would not be useful unless charged to 100 volts, and that the Judge had been satisfied that this could not be done unless they went to 110 volts in charging. Mr. Lane Fox then described very fully what he meant by a large conducting surface, and said that it meant the surface of the plate which was opposed to the next one. The Crompton-Howell plate being granular or porous had a largely extended action surface, but he drew a clear distinction between this and a conducting surface which was practically the surface of the interposed layer of electrolyte which had to conduct the current. Mr. Wallace challenged this distinction, which he said was not to be found anywhere in the evidence, and disputed the difference between the old and the present Planté cells. Mr. Lane Fox, however, contended that a cell could have a large active surface, useful for storage, without increasing the conducting surface to which he alluded in his specification. After the reading of parts of the evidence of Prof. Barrett, Lord Justice Kay asked some questions in which he appeared to think that volts were a measure of quantity, because the volts rise when a battery is full. He therefore could not understand how the "back volts" could rise to 100 immediately. Mr. Lane Fox did not appear to appreciate his lordship's point, and said that he admitted that 101 volts charge would not do for storage but would do for regulating. Mr. Lane Fox concluded his case a little before three o'clock.

Mr. ROGER WALLACE, in reply, said that Mr. Lane Fox alleged that if Planté batteries had been used by the defendants they would not have had any difficulties in their experiments. He could not attempt to dispose of that point without referring to the evidence. In the specification, page 4, line 5, any battery such as Planté's was mentioned, and all the batteries alluded to in this trial were of that description; the evidence showed, indeed, that the Crompton-Howell batteries approached more nearly to Planté's than any other make. He rejected altogether the distinction between active surface and conducting surface. Mr. Lane Fox had given the Court some very interesting information on this point, but there was nothing about it in the evidence; and this information of his was not evidence. He briefly described the Planté cell, the Faure cell, and the Crompton-Howell cell, which was a reversion to the Planté type. He said that the Planté cell had never been used for large installations, and that commercial work had been done only with the later types. The battery used by Prof. Barrett was not a Planté but

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an Elwell-Parker battery. It was true that with a slight rise of volts there would be a certain amount of flow, but it would not be a proper charge. In reply to a question by Lord Justice Kay, he admitted that if the mains had a difference of pressure of 100 volts the battery also would have a similar and equal difference of pressure. When Lord Justice Kay remarked that he thus contradicted what he had said before, Mr. Wallace explained that it would take a long time for the battery to do this. It would be of no use. Mr. Crompton had tried to charge a cell with 101 volts, and after 20 hours only a few amperes had passed. Lord Justice Kay: "Never mind the amperes—how many volts?" After some discussion on this misunderstanding, Mr. Wallace continued that in order to get to 100 volts it was necessary to go to 125 volts. Lord Justice Kay said that that was a question of volts and amperes—he knew what these were as well as electricians, because they did not know what they were talking about. Lord Justice Kay asked what voltage would be maintained if the battery were at 100 volts if the volts in the mains dropped.

The question again arose as to the condition of the mains at 100 volts, and the battery at 100 volts also, and Mr. Wallace used as an analogy the diffusion of liquids by osmosis. Lord Justice Kay said that it was no use trying to explain one unintelligible thing by another unintelligible thing. After a reference by Mr. Wallace to the high standing of the witnesses on his side, Lord Justice Lindley said that Mr. Lane Fox had only suggested that his own witnesses were theoretical, and that those of the defendants were interested. Mr. Wallace referred to Prof. Barrett's evidence, and pointed out that it was only a laboratory affair, there being only 10 lamps altogether. Lord Justice Lindley said that it might, for all that, be very important from a patentee's point of view. Mr. Wallace, continuing, said that the evidence did not describe how these batteries were charged, and showed that there was a large excess of battery power. Mr. Drake's evidence was read, showing that no matter how large a cell may be, it must be charged to 125 volts, in order to produce 100 volts. Mr. Swinburne's evidence on Planté cells was then referred to. He had said that Planté plates suffered from waste or leakage; that large plates were not practicable, that there was local action, and the coatings pealed off. Further argument followed on charging, and the fact that secondary batteries had both internal resistance and back volts was alluded to.

The hearing of the appeal was continued on Wednesday and Thursday. A brief account of the proceedings, which consisted chiefly in the reading of the evidence, will be given in our next issue.

The Brush Electrical Engineering Company (Limited) v. Kingsbury.

The following judgment was recently delivered in the Equity Court of New South Wales by Mr. Justice Manning:—This case was very fully discussed before me upon the motion for an interim injunction, which, beyond all question, should have been turned into a motion for decree; and so strongly did I feel, as a matter of fact, that all the materials were before me on the interim injunction motion for coming to a decision that I made the order with costs. Then it was open to the defendant to appeal, which he failed to do; and his appeal, if upheld, would have made him successful in the suit. On that occasion I was asked to give costs as between solicitor and client, and I declined to do so. I cannot imagine any case upon a motion for an interim injunction when such costs would be given, and I mentioned that the question of such costs would be one for the hearing. It seems to me that if ever there was a case for an order as asked for, this is one. Here is a patent which has been established by the decisions of the Court of Appeal in England. Letters of registration were procured in this colony, and the defendant acted for five years as agent for the Company owning those letters of registration. Subsequently there was an assignment to another company, and eventually to the plaintiff Company, and the defendant ceased to be agent. Then that being so, the defendant becomes agent in this colony for lamps which, beyond all question, are an infringement of the patent rights of the plaintiff Company and of those people for whom he had been acting as agent. He admits infringement in the first instance, and appears to have had sufficient knowledge on the subject by paying a royalty for the importation of these very lamps which he says now are not an infringement. He is warned over and over again. I have no doubt that there was a very fair point of law, and it appears to me it would have been a most disastrous thing to have decided that in any other way than the manner in which I decided it on the injunction motion, and there is nothing new to induce me to alter my views. I must treat this case as one in which the only defence set up has been abandoned. I must look at that defence as showing the whole character of the defence to the suit. Edison, having applied for and obtained a grant and patent rights in England early in November, 1879, applies for letters patent out here, and at that time beyond all question nothing whatever in these colonies was known of this discovery; but between that time when by law he was compelled to disclose his invention and the time of his receiving letters patent, there was an account of the invention in the newspapers, by reason of an application made elsewhere, particulars of the invention appearing in the English newspapers, of which copies were published here. This defence is put forward by a man who has been the agent, if not for the plaintiffs, at least for their predecessors in title. Every obstacle has been thrown in the way, even to compelling a commission to be sent to England to prove the incorporation of these companies; it is to my mind as bad a case of infringement of a patent as I have ever heard of, and I think, therefore, upon every ground, that I am bound to make a decree as asked in terms of the first, second, third, fifth and seventh paragraphs of the prayer of the statement of claim. I think, also, it is a very reasonable request that the defendant should make an affidavit within seven days of all the lamps in his possession, control and custody, referred to in the third prayer of the statement of claim; within seven days of the service upon him of notice of a decree having been made in the suit and of this special order, and further that he deliver up all such lamps as come within the description of the third paragraph of the prayer within four days after service of the decree. And I also think that for the purpose of the inquiry as to damages before the Master, he should make a discovery under Rule 122 of all documents which he has or has had in his possession or power within fourteen days after the service of the decree.

Akers and Iliffe.

We are authorised to state that this action, a report of an interlocutory proceeding in which appeared in our issue of June 3, has now been discontinued by the plaintiff, who has withdrawn all claims and charges against the defendant, and has paid him the sum of £1,750.

CORRESPONDENCE.

NEGATIVE RESULTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a matter of general scientific logic, may I ask on what principle it is assumed that from so-called negative results no certain conclusion can be drawn?

The question arises in connection with an abridged abstract on page 201 of your last issue, and some Notes concerning it on page 184. Suppose that a question to be experimentally examined were whether the earth's gravitative attraction for matter depended on, say, its temperature or its electrical potential; experiment could answer in the affirmative or in the negative, but one answer could be as clear and distinct as the other. There seems to be some ambiguity about this word "negative," because of its two antitheses, "affirmative" and "positive." An answer "no," though a negative reply, may be as decided and *positive* an answer as "yes;" and conclusions may as readily be drawn from the one as from the other. I regard all the negative results of experiments made throughout this century on the connection between ether and matter as being quite as clear and satisfactory as if they had been positive; and I see no reason for desiring one form of answer rather than the other form.—Yours, &c.,

OLIVER J. LODGE.

[Reference is made to this letter in our "Editorial Notes" column.—Ed. *E.*]

MILD STEEL FOR DYNAMO MAGNETS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your review of Dr. Thompson's "Dynamo-Electric Machinery" you suggest that "a word of warning might have been introduced against the use of mild steel both for armature discs and for field-magnets in general cases." As mild steel has been used by dynamo builders for some time now, the warning would in any case have come somewhat late; but, on the principle that it is never too late to mend, will you give us the reason why mild steel should be avoided?—Yours, &c.,

Westminster, June 29, 1892. GISBERT KAPP.

[The whole of that remarkable class of iron which is embraced in the term "mild steel" was not impeached. The word of warning which might have been introduced is that, while charcoal iron is safe, there are many brands of so-called mild steel which are very unsuitable for dynamo construction, as several dynamo makers know to their cost. In special cases, as, for example, in some motors, the residual magnetism of mild steel is useful for field magnets, and the permeability of some brands is so little below that of good soft iron that it pays to use it because it can be more conveniently bought. One brand of mild steel is said to have even higher permeability than good average soft iron, but in many examples of mild steel sheet the hysteresis is serious.—THE REVIEWER.]

CARBON BRUSHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read with great interest the remarks in your last issue regarding carbon brushes. We quite agree with you that, from the absence of carbon brushes at the Crystal Palace, one might naturally come to the conclusion that these brushes were considered of no practical utility by the English dynamo

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and motor makers; but we can assure you, from our experience, that this is not the case. In America and on the Continent the use of carbon brushes has in the last few years greatly extended, this result being due, in a great measure, to the special composition of carbon we have, after lengthy experiments, arrived at, which has enabled us to offer to the trade brushes which keep the commutator in perfect condition, and which effect also a great economy, as the wear and tear of them is practically nil, and the sparking on the commutator, as you remark, is stopped.

We may say that the greatest enemies of carbon brushes have been those who were the most enthusiastic in their favour when they were first introduced, and the reason is that they cannot be applied to all of the existing dynamos. The nature of the insulation of the commutator and the amount of current which the brush has to carry have to be carefully considered before substituting carbon brushes for copper.

In the majority of cases carbon brushes answer perfectly; but in a few cases they do not adapt themselves at all, or very unfavourably; and through these special cases a feeling of prejudice against carbon brushes has been engendered, which has very much retarded their general adoption, more so than one would suppose.

On the Continent carbon brushes are almost universally used for motors, especially for traction work; and the most important firms have modified the insulation and the length of segments of the commutators of their machines so that they may be enabled to use carbon brushes, of which they recognise the advantages. We know some English firms who are working in the same direction, but who were most likely not ready with their machines at the opening of the Crystal Palace Exhibition.—Yours, &c., C. STREET,

Le Directeur Technique Le Carbone.

Levallois-Perret, June 28, 1892.

SENSITIVENESS OF GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of June 17th a Paper read by Prof. Ayrton on "Workshop, Ballistic, and other Shielded Galvanometers" is reported. The Paper deals with the performances of recently constructed d'Arsonval galvanometers, and concludes with an example and a comparison. The words are:—"An instrument of this kind, with a coil of 300 ohms, gave 95 divisions per micro ampere;" and "their sensitiveness is, for the same resistance and periodic time, as great as that of Thomson instruments." Lower down we find the periodic time to have been 5 seconds. Particulars are also given as to the size of the divisions, &c. Greatly doubting the accuracy of this statement, I determined to put it to the test. The instrument used was one of Messrs. Elliott's Thomson galvanometers, its resistance being 1,830 ohms. The periodic time was reduced to 4·5 seconds. In Thomson instruments of similar construction their figures of merit are fairly proportional to their resistances. I found that this instrument gave 90 divisions deflection for $\frac{1}{7340000}$ ampere. If the resistance of the galvanometer had been 300 ohms we should have got a deflection of 95 divisions for $\frac{1}{1100000}$ ampere, in round numbers. This, I may add, is about the ordinary performance of a good Thomson galvanometer. Comparing these figures with the results given above, the immense superiority of the Thomson over the d'Arsonval gavanometer (so far as sensitiveness is concerned) is obvious. The statement made concerning the latter instruments is, therefore, utterly misleading, to say the least of it.—Yours, &c., J. W. FLOWER, JUN.

59, Hartham-road, Camden-road, N., June 27, 1892.

ALTERNATE-CURRENT STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am very much obliged for your Note to my letter of the 6th inst., and also for the letters by Messrs. R C. Jackson, Albert Gay, and James Shepherd, for whose kindness in affording the information contained in the replies I am duly grateful. It is very unfortunate that the poor individuals who are exiled in the provinces should always be told that figures are only given correctly in the Institution *Journal*, and that they should, therefore, be debarred from discussion.

As to parallel running of alternators, there seem to be three sets of plant in this country with which parallel running has been successfully carried out on a practical scale for twelve months or more. These are:—

1. "Ferranti" system. Hick-Hargreave engines. Ferranti alternators. 2,400 volts. 67 ∼. Example: Deptford. Station not run in parallel: Glasgow. Can anyone say how Rochester is worked?

2. "Brush-Victoria" system. Raworth engines. Mordey alternators. 2,000 volts. 100 ∼. Examples: City of London, Bournemouth, Sheffield. Stations not run in parallel: Bath, Chelmsford, Newcastle, Lynmouth, Exeter, Hastings.

3. "Lowrie-Hall-Kolle" system. Fowler engines. Elwell-Parker alternators. 2,000 volts, 70 ∼. Example: West Brompton. Not running in parallel (?): Eastbourne, Brighton.

There are so many cases where parallel running makes all the difference between profit or loss that it is most interesting both technically and scientifically able to ascertain where such method of supply is in use, and if I have been mistaken in any of the above I shall be obliged to anyone who takes the pains to put me right. So far as I am aware, the only other system in use in central-station work to-day and to be continued permanently, is that of Parsons, at Newcastle and District, Forthbanks Stations. On this system, probably parallel running is not such a vital matter, and, therefore, is not attempted. Beyond that we have Thomson Houston at Taunton and Woking, and Kingdon at Weybridge.

I duly read Mr. Gay's article when it appeared, and had seen the station under his charge running in parallel, but the switchboard is so arranged that either "districting" or "paralleling" may be adopted, and I do not think it was well known which practice was in daily use.—Yours, &c.,

44, Hemans-street, Liverpool, CHARLES H. YEAMAN.
June 5, 1892.

SUNSPOTS AND MAGNETIC STORMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Seeing by a late number that M. Janssen has thrown some doubt on the connection between sunspots and magnetic storms, and suggests waiting for news from the Southern Hemisphere *re* the magnetic storm of February 14th last, I think it as well to inform you that on that day (Sunday) a severe magnetic storm was felt on the telegraph lines both east and west; and the quadruplex lines to Sydney and Adelaide were for some time unworkable. Unfortunately, I was at home and knew nothing of it till next day, when the phenomena were not to be observed, and none of the operators in the chief office made any exact observations. At the same time an enormous sunspot was visible.

Again, on November 18, 1882, a similar magnetic storm was felt both here and in Scotland and Northern Europe at precisely the same time. An E.M.F. of quite 100 volts was visible on the main Sydney line, which was always waxing and waning and reversing. Work was quite suspended from 8 p.m. (when the storm was at its height) till 10:35 p.m.; at that time I believe sunspots were very marked. I enclose a memo from the Government Astronomer in answer to a query.—Yours, &c.,

H. W. JENVEY, Electrician,
Postal Department, Victoria.

General Post Office, Melbourne, Victoria,
Australia, May 18, 1892.

Telegram from Observatory. Melbourne, Victoria,
For Mr. Jenvey.

Magnetic storm commenced Saturday very strong. Continued till yesterday, when disturbance fell off. The immense sunspot is cause.

R. L. J. ELLERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The connection between the variations of the earth's magnetism and the passage of faculæ and spots over the sun's disc, or, in other words, that there is a correspondence between the periods of maximum magnetic disturbance and those of maximum sunspot intensity, has received additional con-

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firmation by the recent magnetic disturbance of February 13th and 14th.

Simultaneously with the appearance of earth currents on February 13th, on the European lines, a similar phenomenon was observed on the Indian lines at the Central Telegraph Office, Bombay.

The earth currents began to be first felt on all the lines running S.E. at 10:25 a.m. Madras time, or 5 a.m. Greenwich, they extended to the N. and N.W. lines gradually; the last mentioned continued to be affected till noon of the 14th. They were very variable, and at intervals very strong, particularly on the lines running S.E. The impulses were in both directions, changing rapidly from + to − within a few minutes. Their frequency it was difficult to determine, while the potential was at times much higher than our normal working currents, which on a duplex line is as much as 10 milliamperes. Outgoing traffic on all the lines was much retarded while the disturbance lasted, which was most felt between the hours of 10:25 a.m. and 2:30 p.m. Madras time.

The Madras Railway Company's lines were temporarily interrupted, the signallers complaining of strong left and right deflections.

The Madras-Penang cable, while under test on the 14th, was traversed by an earth current of a strength equal to that which would have been produced by a battery of 25 volts.

On May 18th and 19th strong currents were again observed on the Government and railway lines, but not of that intensity as those of February 13th, the lines running N.N.E. being more affected than any others.

Since the 24th inst. a sunspot has been visible to the naked eye in this locality; it is best observed at sunset at about 7 p.m. (Madras time), and it would appear to have but recently come on the disc (East limb).—Yours, &c.,

Deesa, May 28, 1892. C. P. O'Reilly, Indian Telegraphs.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Tenders Invited.—The Asylums Committee of the London County Council are prepared to receive tenders for the generating plant and principal mains required for the installation of the electric light at the London County Lunatic Asylum, in course of erection or completion at Claybury (Woodford), Essex. Printed forms of tender, contract (with specification and schedules annexed) and bond, and lithographed copies of the drawings, can be obtained of the Clerk of the Committee at their offices, 40, Craven-street, Strand, on payment of £5 (returnable on a bonâ fide tender being delivered); and tenders must be delivered at the offices of the Committee not later than noon on the 26th inst. Further particulars appear in our advertisement columns.

——— The Committee of the Glasgow Town Council on Gas Supply and Electric Lighting invite tenders for the providing and erecting of (1st) steam engines and pipes; (2nd) dynamos, switchboard, and connections, &c.; and (3rd) arc lamps. Plans and specifications may be seen and forms of tender obtained on application to Alexander B. W. Kennedy, Esq., 19, Little Queen-street, Westminster, or at the Gas Office, 45, John-street, Glasgow. Sealed offers, marked "Tender for Steam Engines and Pipes," or as the case may be, will be received by Sir J. D. Marwick, LL.D., Town Clerk, on or before Tuesday the 12th July.

——— The Art Gallery Committee of Manchester invite suggestions and tenders from electrical engineers as to the best method of illuminating the entrance hall at the Art Gallery, Mosley-street; also for the lighting of the two new galleries with incandescent lamps similar to the system now in use at the present galleries. The various lights are to be supplied from the present dynamos. Particulars may be obtained at the City Surveyor's office, Town Hall, Manchester, where tenders are to be delivered by the 7th inst.

——— The municipal authorities of Mahon, in Spain, will receive tenders until July 14, for the electric lighting of that town.

——— The Spanish Colonial Minister invites tenders for the installation and working of a telephone exchange at Mantanzno, Cuba. The caution money is 400 pesos, and tenders must be in by August 8.

Tenders Accepted.—The Chiswick Local Board have signed an agreement with Messrs. Bourne and Grant for the lighting of the parish by electricity, subject to the approval of the Board of Trade.

——— The City of London Electric Lighting Company (Limited) have accepted the tender of Mr. W. Shurmur for the erection of engine and boiler-house at Meredith Wharf, Bankside, S.E., for the sum of £6,610.

Haiphong, Tonkin.—The Compagnie Continentale Edison have just concluded a contract to instal the electric light at Haiphong.

Vaughan-Sherrin Electrical Engineering Company (Ltd.)—Notice is given by Mr. S. Hedges (liquidator of this Company), of 15, George-street, Mansion House, E.C., that creditors are required to send in their names, addresses, and particulars of their claims to him by the 29th instant.

Messrs. Thomas Barraclough and Co. (Limited).—At a meeting of the shareholders of this Company (carrying on business in Manchester as wire-covering machinery manufacturers), held on June 22nd, it was resolved to wind up the Company; Mr Alfred Tongue, of 44, Brown-street, Manchester, being appointed liquidator.

International Exhibition Association of Electrical Engineering and Inventions, 1890.—All claims against this association are to reach the liquidator, Mr. J. A. Robertson, 33, Charlotte-square, Edinburgh, by to-morrow (Saturday).

Froude-Hurrell Torpedo Company (Limited).—Mr. Justice Vaughan Williams will on Saturday (to-morrow) hear a petition presented by Mr. M. H. Hurrell for the compulsory winding up of this Company.

Excelsior Copper Company (Limited).—A petition is to be heard at the Royal Courts of Justice on July 7th for the compulsory winding up of this Company.

Crystal Palace Exhibition.—The following information has been issued by the Crystal Palace authorities:—"The London, Brighton and South Coast and the London Chatham and Dover Railway Companies have agreed to convey unsold exhibits originally sent from stations on their lines on the return journey free of charge, at owners' risk, on production of a certificate signed by Mr. Henshaw Russell that such exhibits remain the property of the exhibitors. It will be necessary before any certificate will be issued, that a written application be made to Mr. Russell at the Palace, setting forth that the exhibit to be conveyed remains the property of the exhibitor."

Messrs. J. and G. Odhams.—We have received the fourth edition of the illustrated catalogue issued by this firm, containing particulars of the various electrical specialities manufactured or sold by them.

Messrs. J. G. Statter and Co.—This firm have just secured the contract for two electrical cranes for the Southampton Harbour Board, and also for three 23-unit dynamos for the electric light installation at Lord Rothschild's establishment at Tring Park.

The Imperial Institute.—Messrs. Julius Sax and Co. have supplied the whole of the internal telephone exchange system for this Institute. This exchange system is connected with 40 outlying stations.

Roper's Electrical Engineering Company (Limited).—This firm have recently completed a large installation of the electric light at the Alhambra, Hull. A 16-H.P. Tangye gas engine with a 20in. stroke and two 6ft. fly wheels is used. The installation has proved a great success.

Messrs. Trackson Brothers, of Brisbane.—This firm have recently supplied the electric light fittings for the Parliament buildings at Brisbane.

International Exhibition of Building Materials.—An international exhibition of building materials is to be held at Lemberg, Austria, from August 30 to September 20, and the list of exhibits includes telephones, electric bells, and general electric housework.

Another Exhibition.—An exhibition of laundry and domestic appliances is to be held at the Central Hall, Holborn, W.C., in August next, under the management of Messrs. Harry Etherington and Co.

An Electrical Sailing Gig.—We are notified that amongst the latest orders received by Mr. Sergeant is one for an electrical sailing gig for the Norfolk Broads. The boat is to have a specially designed motor, the accumulators used being of the E.P.S. T type, consisting of 19 plates. These are to be placed below the water line. It will be possible to either row, sail, or propel electrically at the will of the owners. The boat is built to accommodate six persons.

International Tariff Changes and Customs Regulations.—The last issue of the *Board of Trade Journal* contains a number of modified Customs tariffs, including those for Sweden, the Niger Territories, and Trinidad. The new duties for Sweden include a reduction of 5 per cent. on the *ad valorem* duty on electro-meters, and an increase of 10 per cent. on the *ad valorem* duty on steam

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engines, machines, implements, and tools. Leather and other driving belts, cast-iron tubes and pipes, steam engines and boilers (not otherwise specified), are now admitted free. For the Niger Territories all merchandise of an electrical character is admitted free. Under the new Customs tariff of Trinidad, copper, bronze, zinc, and lead articles for domestic and building purposes, india-rubber and gutta-percha goods, telegraph wires, and all electrical instruments and appliances for communication and illumination, steam engines and similar machinery, are free of duty. The same number of the Journal contains particulars of the Treaty of Reciprocity between Guatemala and the United States; materials for electric lighting and materials for the construction of railways and their equipment, are admitted into Guatemala from the United States free of duty.

THE "DAILY CHRONICLE" AND "LLOYD'S NEWSPAPER."—A large gathering of gentlemen interested in the development of rotatory printing machines met at the printing and publishing offices of the *Daily Chronicle* at midnight on Friday last to witness the new machinery installed by Messrs. Hoe and Co. There are eight machines in all, each capable of producing 24,000 copies per hour of the *Daily Chronicle*, including the pasting in of the two-page literary supplement. This is one of the finest sets of rotary machinery for printing purposes to be seen in London, and though somewhat intricate, the progress of the work can be observed by the man in charge of the machine during the whole operation. This is rendered possible by the application of the electric light; several incandescent lamps are installed in each machine, so that the interior of the machine from the time the paper enters to the completion of the work is brilliantly lighted, and the slightest accident to the sheet while travelling can be observed. Those of our readers acquainted with printing machinery will understand how very important this feature is with a machine travelling at the rate of 24,000 copies per hour; in fact, we question whether without the electric light it would be safe to drive the machine at this extreme speed, as but a moment would suffice to choke the machine with spoilt paper if a break in the sheet, or any similar accident, were unobserved by the attendant. The electrical work has been well done by Messrs. Paterson and Cooper.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

10,603. B. M. DRAKE, J. M. GORHAM, W. C. JOHNSON, and S. E. PHILLIPS. London. Improvements in electrical accumulators.

10,609. W. S. SIMPSON. London. The protection of insulating material or cable, line, and like electric wires to preserve the insulating material from atmospheric and other destructive media, and for preventing escape of sound vibrations from telephone wires.

June 4, 1892.

10,632. C. T. P. BRAIN. Liverpool. Improvements in electric switches.

10,651. H. T. SULLY. South Woodford. An improvement in ceiling roses (or fittings) for use with pendant electric light fittings.

10,653. H. HELBERGER. London. Apparatus for automatic calculation of electric gas or water distribution.

10,690. T. PARKER and A. E. ROBINSON. London. Improvements in anodes for use in electric cells for treating chlorides, fluorides, or other compounds, and the like.

10,696. A. SHIELS. London. An improved detector cover for electric push-knobs and the like.

10,706. W. S. SMITH and W. P. GRANVILLE. London. Improvements in effecting electric telegraphic communication, applicable especially for telegraphing to lighthouses, either floating or on rocks, at a distance from the shore, or for telegraphing to and from vessels.

June 7, 1892.

10,715. C. F. JACKSON. London. Improvements in conductors for the distribution of electrical-energy.

10,716. C. R. G. SMYTHE. Glasgow. Improvements in and connected with junctions for electrical conductors.

10,735. H. C. BULL. Liverpool. An improved process and apparatus for making sodium, potassium, and like metals by electric action, and producing ferric chloride as a dry powder.

10,742. R. STEENBERG. Newcastle-on-Tyne. Improvements in or relating to electric telegraphic signals—receiving apparatus.

10,762. E. E. WEAVER and G. B. MANYPENNY. London. Improvements in incandescent electric lamps.

10,777. THE PRINCESS COMPANY (LIMITED). London. Improvements in electric batteries. (The Princess Company (Limited), Mersch.)

10,783. T. CASSON. London. Improvements in electro-pneumatic action for organs.

10,818. C. BOLLÉ. Manchester. Improved electrical insulating conduit. (Charles W. Jefferson. United States.)

June 8, 1892.

10,823. E. W. BULLER. Birmingham. Improvements in the construction and attachments of insulators for telegraph, telephone, and such like purposes.

10,847. R. N. LUCAS, A. J. MAYNE, and A. GEORGE. London. An appliance for actuating an electric transformer switch.

10,850. H. WEYMERSCH. London. Improvements in primary voltaic batteries.

10,855. H. F. KIRKPATRICK-PICARD, and H. THAME. London. Improvements in secondary batteries.

10,870. H. H. LAKE. London. Improvements in electrical measuring instruments. (E. Weston, United States.)

10,873. C. A. MCEVOY. London. Improvements in electrical indicator apparatus.

10,876. J. A. TIMMIS. Westminster. Improvements in the reflection and distribution of the electric light.

June 9, 1892.

10,932. W. J. BIRNIE. London. Improvements in secondary batteries for electric lighting and power.

10,945. A. W. DAVIES and P. R. NUNES. London. An improved electrical advertising device.

June 11, 1892.

11,032. J. T. HARRIS. London. An improvement in insulating supports for electrical conductors led in culverts.

11,038. G. BINSWANGER and H. J. COATES. London. Improvements in electric signalling apparatus.

11,041. V. G. LARONI. London. Improvements in "electrical safety devices."

June 13, 1892.

11,050. D. COOK and E. PAYNE. London. Improvements connected with tubular electric conductors.

11,067. W. A. PERRY. Birmingham. Improvements in and connected with joining the ends of telegraph and of telephone and other wires, and in machines for preparing the said ends of the wires.

11,071. W. SMETHAM. London. Improvements in electrical apparatus for scoring in billiards or other games, applicable also for showing the number of revolutions of marine and other engines, and for other purposes.

11,085. WOODHOUSE AND RAWSON UNITED, Limited. London. Improvements in electrical indicators. (R. Varley, United States.)

11,087. W. L. WISE. London. Improvements in galvanic batteries. (T Rosati, E. Righetti and G. O'Connel, Italy.)

11,096. A. C. MOLL. London. Improvements in or relating to telegraphic instruments.

11,014. H. HAMMARLUND. London. Improvements in telephonic apparatus.

June 14, 1892.

11,119. F. BROADNAX. Liverpool. Improvements in electric switches.

11,126. J. PATERSON. Lancashire. An improved element by the acid of which a current of electricity may be generated.

11,141. J. E. WEYMAN, G. HITCHCOCK and J. A. DRAKE. Sheffield. Improvements in hydrocarbon motors, and in apparatus and appliances connected therewith.

11,147. H. H. LLOYD. London. Improvements in secondary or storage batteries.

11,154. W. P. THOMPSON. Liverpool. Improvements in the method of welding metals electrically. (C. L. Coffin, United States.)

11,181. W. PETCHEY. London. An improved construction of electric alarm clock.

11,192. T. REID. London. Improvements in and relating to the driving of dynamo-electric machines, and in apparatus therefor.

June 15, 1892.

11,194. B. M. DRAKE and J. M. GORHAM. London. Improvements in indicating apparatus for high-tension circuits.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

9,642. WATT. Electric arc lamps.

13,252. FÉRY and DUCRETET. Electrical contact-making and breaking devices.

13,367. SLOPER. Electric telephone switches, &c.

13,802. SOHLMAN. Electric current generator.

14,509. MILLS. Electrical transmission of power.

19,495. POWERS and VAN BUREN. Electrical conduits, &c.

1892.

2,055. WISE (BERTOLINI). Closing electric circuits.

6,181. WOOLLEY. Electric fire alarm.

8,242. HASELWANDER. Electrically propelled vehicles.

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PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS.—THURSDAY, JUNE 23RD.

Select Committee on the Electric Railway Bills.

The Select Committee of the House of Lords, presided over by the Marquis of Waterford, met again to-day, and resumed their consideration of the Baker-street and Waterloo Railway Bill. Sir Benjamin Baker gave evidence as to the interchange to take place between the St. John's Wood branch of the Metropolitan Railway and the new line. The station of the Electric Railway would be constructed under the sidings and at the end of the platform of the existing St. John's Wood Railway. A subway would probably be constructed right across the whole of the lines, and accesses given to it from the lower station communicating with the upper. The interchange would be from the low-level platform of the electric railway to the high-level platform of the St. John's Wood Railway. In the proposal of the electric railway the distance between the two platforms would be 30ft. The Chairman directed that a clause should be inserted in the Bill providing that separate shafts for ventilation, not less than 5ft. in diameter, should be constructed at all the stations. The clauses of the Bill were then gone into, and the Bill ordered to be reported for third reading. The Bill will pass through its final stages in the next Session of Parliament.

FRIDAY, JUNE 24TH.

The Great Northern and City Railway Bill came before a Committee of the House of Lords, presided over by Lord Poltimore, on Friday. The only opponents to the Bill in this House were the Metroplitan Railway Company. After Mr. Greathead, the engineer to the line, had given evidence, Mr. Moon, on behalf of the promoters, submitted to the Committee whether, in view of the favourable report of the Joint Committee of both Houses on the question of electricity as a motive power, they would require evidence on that subject, which elicited from the Chairman a declaration that the Committee were satisfied on that point. Sir Albert Rollit, M.P. for South Islington, expressed the views of his constituents in favour of the line, the district being densely populated, and much in want of railway accommodation. Other local witnesses also gave evidence as to the overcrowding on the North London and Great Northern lines; and Sir Henry Oakley, the General Manager of the Great Northern, confirmed these statements, and said that with the present means it was utterly impossible to cope with the enormous traffic, especially in the morning and evening. The scheme was therefore welcomed by the Great Northern Company, which would run through trains. He was severely cross-examined by Mr. Worsley Taylor as to whether the support accorded by the Great Northern to the scheme was not an abrogation either of the spirit or the letter of an agreement between the Metropolitan and Great Northern Companies, under which the latter already obtained access to Moorgate-street over the former Company's lines, and in respect of which they were bound to pay a minimum sum of £7,000 a year, though the payment in recent years had been as much as £24,000 a year. Mr. Worsley Taylor asked the Committee if they passed the Bill to annex to it conditions providing either for the termination of that agreement or that the Great Northern Company should be bound in future to pay to the Metropolitan Company the amount which they were at present paying. The Committee, after a private consultation, said they were unanimously of opinion that the opponents had failed to make out a case, and passed the Bill.

The Waterloo and City Railway Bill, which will be proceeded with next Session, has been read a second time and committed.

COMPANIES' MEETINGS & REPORTS

West Coast of America Telegraph Company (Limited).

The fifteenth ordinary general meeting of this Company was held last Monday at Winchester House, Old Broad-street, under the presidency of Mr. Henry Roberts.

The SECRETARY (Mr. Fred. L. Robinson) read the notice calling the meeting and the minutes of the last meeting.

The CHAIRMAN then said: Gentlemen, I presume it is your pleasure that the report and accounts be taken as read. Before moving their adoption I wish to take this opportunity of referring to the loss we have sustained by the death of the late Chairman, Mr. Alfred Marshall. He was a gentleman who took a keen interest in the affairs of this Company; and his geographical and commercial knowledge of all the ports and places our cables touch, rendered him invaluable to this Company, and we all deeply deplore his loss. Referring to the report and accounts, the gross earnings, although showing a very large decrease as compared with the previous year, may be regarded as satisfactory when all circumstances are taken into consideration. The year under review was ushered in with the revolution in Chili, which was not terminated until the end of August. The cables of this Company connecting the principal ports of Chili were interfered with by both parties, the war vessels of the Congressionalists cutting the Mollendo-Arica and the Arica-Iquique sections on February 4th, the Iquique-Antofagasta section on February 6th, and the Antofagasta-Caldera section on March 17th. These cables were all repaired between April 17th and May 6th, so soon as the then existing condition of affairs permitted our repairing steamer to do the work. The Mollendo-Arica and Arica-Iquique sections were closed for public traffic by order of the Congressionalists from the 10th to the 24th August, and the stations at Santiago, Valparaiso, and Serena were closed to the public from January 20th to March 19th, and from April 1st to September 1st, by order of the Balmaceda Government. They paid us some compensation for stopping our business until March 18th. With regard to the cutting of our cables, we have preferred a claim for the expenses incurred in effecting the repairs, and this matter is now under the consideration of the Government of Chili. I may mention that all the expenses of these repairs have been charged to the revenue account of last year. The West Coast expenses show a decrease of nearly £3,000 as compared with the previous year, principally due to staff alterations, and partly to the low rate of exchange. The working expenses of the steamer "Retriever" show little alteration; during the year the vessel passed her third survey under the regulations of Lloyds' Committee. The item of £150 in the accounts for the Directors' 5 per cent. on dividends refers to the final dividend of 2s. per share for the year 1890, paid in May, 1891. The London office salaries are slightly increased, in consequence of some clerical work being transferred from Lima to London, by which an actual saving of about £300 per annum is effected. The negotiations with the Brazilian Submarine and the Western and Brazilian Telegraph Companies, conducted under the presidency of Sir John Pender, K.C.M.G., have been brought to a satisfactory termination, resulting in the formation of a new company. The share capital of the Company (£100,000) will be held by the Brazilian Telegraph Companies and this Company. The line being worked for our joint benefit, and connecting, as it will do, the ports of Valparaiso and Buenos Ayres, will give us a connection with the Brazilian Companies and the Eastern Telegraph Company over a line duplicated throughout, and opening up a rapid and efficient service between the West Coast and Europe *vid* Lisbon. The new land line is already in course of construction. In addition to the share capital, one quarter of which will be held by us, there will be an issue of £100,000 Debentures, to which you will have an opportunity of subscribing. Our competitor, the American Company, having acquired, since the 1st January, 1892, the existing land line between Valparaiso and Buenos Ayres, so adjusted the tariffs as to exclude us from participating in any European traffic at our principal stations; and this state of things will continue until the new line is completed, when the public will have the benefit of a service which will carry messages between Europe and the West Coast of South America, entirely over lines owned by English companies, and worked by English operators. It is, of course, impossible to say how far we shall benefit by the new and improved service, but we may at least expect a fair share of the traffic to and from Europe; and this traffic is a growing one. With regard to our earnings during the present year, it has been thought desirable, owing to the competition, not to publish, or issue in any form, the monthly receipts. This course is absolutely necessary for obvious reasons. Before concluding my remarks, I have to express the satisfaction of your Directors at the decision of Mr. J. Denison Pender to allow himself to be nominated at this meeting for election to a seat at the Board; the shareholders will appreciate the weighty considerations involved in this addition to our strength, particularly at the present juncture in our affairs. I now formally propose:—

"*That the report and accounts for the year ended December 31, 1891, now presented, be received and adopted.*"

Mr. FREDERICK WALTERS seconded the motion, which was unanimously adopted.

The CHAIRMAN: The next resolution is one of the most valuable that I have ever had the pleasure of proposing to a meeting. It is as follows:—

"*That Mr. John Denison Pender be elected a Director of the Company.*"

Mr. WALTERS seconded the motion, which was unanimously agreed to.

Mr. T. R. PACE proposed the re-election of the retiring Directors, Mr. Roberts and Mr. Walters. He said he was quite sure that the shareholders, as business men, all felt that those two gentlemen had rendered the Company very great services during a period of extraordinary trial. It was rarely that a business of any kind in one year was subjected to the trials which their Company must have been subjected to last year—a revolution, with, for a long time, absolute ignorance as to when it was going to terminate; the laying of a rival cable, which for a time, apparently, took the whole of their European business from them; and last, but probably not the least, in the midst of all this trouble losing the Chairman. He thought the shareholders would all understand the great services and attention which the Directors must have given during the past year. No doubt, a separate vote of thanks would be passed to them, and therefore he would not say more in proposing their re-election than this—that the shareholders felt glad that, after all the trouble they had experienced in conducting the affairs of the Company, they were still willing to be re-elected. The past year had brought the Company from its position of being almost in a *cul de sac* to a connection with the large English companies, and thus recovering a fair share of the English traffic.

Mr. LAMONT seconded the motion, also referring in appreciative terms to the services which Mr. Roberts and Mr. Walters had rendered.

The resolution was carried unanimously.

Mr. J. TAYLOR said he was sure that all who were connected with the Company would regret that Mr. Weise had been forced, owing to the state of his health, not to seek re election. It would, however, be a satisfaction to the shareholders to know that his place was proposed to be filled up by a member of the same eminent firm. He proposed the following resolution:—

"*That Mr. John Francis Clarke, of Messrs. Turquand, Youngs and Co., be elected auditor for the present year, with a remuneration of 25 guineas.*"

Mr. BICKLEY seconded the motion, which was unanimously adopted.

The SECRETARY afterwards read the notice given in calling the meeting, relating to the consideration of the following resolution:—

"*That the regulations of the Company contained in the Articles of Association be altered in the following manner, viz., by inserting in Article*

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11, at the end of the third line thereof, the words 'or making purchases in,' and inserting in the fourth line thereof, after the word 'upon,' the words or in.'"

In answer to Mr. TAYLOR,

The SOLICITOR stated that under the Articles of Association, as they stood at present, the Company's powers of investing were too limited. It had already transpired at the meeting that the Company would have to purchase shares in the new Pacific line, and the proposed alteration was mainly suggested by that consideration.

The CHAIRMAN, in further reply, stated that they had not the full powers which they required, and which the passing of the resolution would give them.

Mr. TAYLOR: The alteration will not give the Company power to purchase its own shares?

The CHAIRMAN: We cannot invest our funds in our own shares or debentures.

On the motion of the CHAIRMAN, seconded by Mr. WALTERS, the resolution was unanimously agreed to.

A vote of thanks to the Chairman and to Mr. Walters brought the meeting to a close.

Eastbourne Electric Light Company (Limited).

The annual meeting of this Company was held on the 29th ult., at the Clifton Hotel, Eastbourne, under the presidency of Alderman G. Bourton (the Chairman of the Company).

The Directors' report alluded at length to the agreement with the late managers, which expired on December 31st last, since which date the Directors have resumed their direct charge over the working of the Company. The financial arrangements with the late managers had been settled in the most amicable manner. During the period of working by the managers, they had received and paid everything, so that the Directors had no accounts to submit to the shareholders, but now that they had reassumed control that duty became obligatory on them. Accompanying the report were the accounts for the fifteen months from September 30, 1890, when the Provisional Order obtained by the Company took effect, to December 31, 1891, which showed that a gross profit of £1,950. 0s. 8d. was earned by the Company over and above the working expenses during that period. In order to attract customers for the current, the Directors had decided to reduce the charge per Board of Trade unit from 10d. to 9d., from June 30th; and they hoped that the increase of business would fully compensate the Company for the reduction in lighting rental which this would entail.

The CHAIRMAN, in moving the adoption of the report, gave a *résumé* of the history of the Company from its registration in 1882, and then said that the earnings of the Company in 1886 to September were £1,679, in 1887 £2,263, in 1888 £3,529, in 1889 £4,053, and in 1890 £4,539. The figures included receipts for installations, costs of charges, wiring houses, &c. As to the progress they were making, in December, 1885, they had 725 10 c.p. lamps, 1,800 in 1886, 2,889 in 1887, 3,451 in 1888, 4,555 in 1889, 5,451 in 1890, 6,293 in 1891, and 6,613 in 1892. He thought that in itself showed a very satisfactory total in the working of that Company. In addition to these lamps they had orders for 64 more at present; and he had no doubt, when it became known they proposed to reduce the price from 10d. per unit to 9d., that they would go on increasing the number of lights very rapidly.

The report was adopted; and votes of thanks were accorded to the late managers, Messrs. Harvey, Henderson, and Hammond, and to the Chairman.

Resolutions were also carried—(1) approving and adopting the agreement under which the business had been transferred from the managers to the Company; (2) authorising the creation of a First Mortgage Five per Cent. Debenture Issue of £25,000, payable on or before January 1, 1902; and (3) agreeing that the property of the Company, the goodwill of the business, and the Company's rights and interests under the Provisional Order should be taken at £32,120 on December 31st last, provided that £625 be set apart out of the present cash balance to a renewal fund.

West African Telegraph Company (Limited).

The following is the report of the Directors to the seventh ordinary general meeting, to be held at Winchester House, on Friday, 22nd July, 1892, at 12:30 p.m.:—

The Company's revenue for the twelve months ended 31st December, 1891, amounted to £60,214 5s. 11d., against which £20,883 8s. 5d. is charged for ordinary expenses, £2,213 8s. 3d. for expenditure relating to repairs of cables, &c., and £755 19s. 8d. for income tax, leaving a balance of £36,361 9s. 7d. From this amount is deducted £23,722 8s. 4d. (being for interest on debentures £13,555 15s. and for sinking fund £10,166 13s. 4d.), leaving a balance of £12,639 1s. 3d., out of which the Directors have placed £3,395 9s. 3d. to the general reserve fund.

The shareholders have received for the six months ended 30th June, 1891, an interim dividend amounting to 3s. per share, and the Directors now recommend a final dividend of 5s. per share, making together 4 per cent., free of income tax, for the year ended 31st December, 1891; which, with the appropriation to the general reserve fund of £3,395 9s. 3d., will absorb the balance standing to the credit of the revenue account.

A considerable portion of our income is derived from the guarantee of traffic by the Portuguese Government. Our revenue has been seriously affected by the depreciation of Portuguese currency, a loss of over £6,800 having been made during the year on the remittances between Portugal and England. The Board are, however, endeavouring to have this question settled on a more satisfactory basis.

During the twelve months under review the cables of the Company have continued in good working order. On February last, however, the cable between San-Thomé and Loanda was interrupted, but was promptly repaired by one of the Eastern Company's cable ships, the cost of which will appear in next year's accounts. The Bolamo-Bissao cable was broken on the 21st April last, but as the interruption of this section did not seriously affect our traffic, the Directors deemed it expedient to delay the repair until the arrival of the Eastern Company's cable ship, "John Pender," *en route* for the Cape. The cable is now restored.

A new station-house has been erected at San-Thomé, and also a commodious and well-ventilated building at Grand Bassam; these buildings will greatly add to the comfort and health of our staff there.

The Directors who retire by rotation are Sir John Pender, K.C.M.G., and Robert Kaye Gray, Esq., who, being eligible, offer themselves for re election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also offer themselves for re-election.

The Chili Telephone Company (Limited).

The following is the report of the Directors to be presented at the meeting to be held at Winchester House, E.C., on Friday, the 8th inst., at 11 o'clock:—

The Directors regret that the business of the Company during the past year has been less profitable than that of the two previous years. This unfavourable result is due solely to the political and other abnormal calamities which befell the Chilian nation, and affected adversely the affairs of the Company. The civil war in Chili is happily at an end, and the industrial as well as the political position of the country is steadily resuming a more settled and prosperous character. Whilst the affairs of the Company for the past year have suffered from the misfortunes of Chili, there is every indication that they will share largely in the return of the national prosperity.

The income from subscriptions and other sources, which in 1890-1 was $387,110, has fallen for the year 1891-2 to $378,850, showing a deficiency of $8,280, which appears very small when it is remembered that the system of the Company was monopolised by the State, and its use by the public suspended for eight months; whilst the destruction of its poles and lines by the retiring troops of the late President, by extensive incendiary fires, and by a snow-storm, such as has not been known in Chili for a century, delayed the resumption of the ordinary business of the Company. The lines have been gradually, steadily, and as promptly as possible, restored, and the subscribers re-connected with the exchanges; so that the number of subscribers now served is nearly, if not quite, equal to what it was before the Civil War began.

The public disasters before-mentioned have increased the cost of maintenance and operating from $102,234 for 1890-1 to $165,400 for 1891-2 = $63,166. The general expenses have increased from $92,826 to $105,780 = $12,954, in consequence of the larger number of dollars paid to *employés* on account of the greatly reduced value of the dollar. Under the above headings there has been a diminution of revenue of $8,280; with an increase of expenditure of $76,120; and, therefore, a less favourable result in Chili by $84,400.

As the bulk of the increased expenditure has been caused by the revolution, a claim has been made against the Government, of which $115,000 remains unpaid. No part of this sum has been treated as an asset in the Company's accounts; whatever may be hereafter received from the Chilian Government will be credited to future revenue.

The deficiency of profit, shown in paragraphs 5 and 7 of the report, has been further increased by the reduction in the rate of exchange, caused by the unfavourable financial conditions prevailing in Chili, from an average of 24d. to the dollar, in 1890-1, to 19½d. in 1891-2; so that, while the profit has been reduced by $84,400, the result in London has been further lessened by the fall in the value of the dollar. The net result of the working in Chili, in sterling, was in 1890-1, £19,205, and in 1891-2 only £8,746; showing the heavy deficiency of £10,459. The expenses in London have been reduced by £254, and the value of the dollar on March 31, 1892, was more than in March, 1891, by 1d., which improved the balance of revenue, so that, taking all the items touching the transactions out of Chili together, a benefit accrued of £2,837, leaving the net deficiency, as compared with 1890-1, £7,622.

The balance of profit in sterling for the year was £6,067, which, with the balance brought from last year, viz., £14,209, makes £20,276 available for division. As the profits have been used for capital purposes they cannot be divided in cash, but the Directors recommend that deferred warrants be issued for 10 per cent. on the share capital, and that these warrants—at the option of the holders thereof—be accepted by the Company for ordinary shares, which will carry dividend from April 1, 1892.

It will be observed that the capital outlay for the past year was £18,720 14s. 7d. This is due to the construction of new trunk lines, to increased capacity in pole routes during re-construction, and to preparation for connecting additional subscribers with the exchanges, whilst at the same time adding to the efficiency of the telephonic plant throughout the Company's entire system. It is anticipated, however, that such further outlay of capital as may be required will be mainly for the purpose of connecting new subscribers to the system, and thereby augmenting the revenue.

The general manager in Chili has succeeded in securing contracts for ten years with the Government, and, for a like period, with the Municipalities of Santiago and Valparaiso, by which the Company materially strengthens its position.

In accordance with the Articles of Association, Mr. Frank W. Jones retires from the Board of Directors, and, being eligible, offers himself for re-election. The auditor, Mr. Thomas A. Welton, also retires, and offers himself for re-election.

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NEW COMPANIES, STATUTORY RETURNS, &c.

[In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "The Electrician" Electrical Trades Directory and Handbook, 1892, pages 308-322, &c., &c.]

HIRST AND COMPANY (LIMITED).—This Company was registered with a capital of £5,000, in £1 shares, on the 27th ult.; to acquire, take over as a going concern, and carry on in all its branches, the business of mechanical and electrical engineers, and manufacturers of and dealers in labour-saving appliances, scientific and other instruments and apparatus, now carried on at Croydon, under the style or firm of Hirst and Company.

LONDON ELECTRIC MANUFACTURING COMPANY (LIMITED).—This Company was registered on the 24th ult. with a capital of £10,000, in £1 shares. The objects are to carry on the business of electrical engineers, electricians, engineers and contractors, suppliers of electricity, manufacturers of electrical apparatus, mechanical and chemical engineers, and of producers of light, heat, sound, and power by electricity, galvanism, magnetism or otherwise. The regulations of Table A mainly apply. The subscribers are:—

	Shares.
R. T. Harrison, 1, St. John's-terrace, Highbury-park, N.....	1
G. Shaw, 39, Waddon-old-road, Croydon.....	1
F. Day, 55, Tubbs-road, Harlesden	1
W. G. F. Hunt, R.N., Mickleham, Dorking	1
A. B. Coombs, 57, Clarendon-road, Walthamstow	1
J. S. Hooper, R.N., 11, Comeragh-road, West Kensington, W.	1
A. Barrenger, 40, Wightman-road, Harringay, N.....	1

MEITER SYNDICATE (LIMITED).—This Company has been registered with a capital of £15,000, in £10 shares, to carry into effect an agreement, made June 18, between C. W. Meiter of the one part and C. E. Gudgeon, on behalf of this Company, of the other part, and to carry on business as manufacturers of and dealers in caoutchouc, gum, gutta-percha, &c.

PACIFIC AND EUROPEAN TELEGRAPH COMPANY (LIMITED).—This Company was registered on the 24th ult., with a capital of £100,000, in £10 shares. The objects are to purchase, acquire, construct, or cause to be manufactured, wires and cables of all kinds for the purpose of telegraphs and telephones; to enter into and carry into effect an agreement between the Brazilian Submarine Telegraph Company (Limited), the Western Brazilian Telegraph Company (Limited), the West Coast of America Telegraph Company (Limited), the Pacific and European Telegraph Company (Limited), and Sir John Pender, K.C.M.G., for the construction and maintenance of telegraphic communication between Buenos Ayres, in the Argentine Republic, and Valparaiso and Santiago, both in the Republic of Chili; and to construct, maintain, and work, or to promote any other company to construct, maintain, and work, telegraphs, telephones, electric light works, &c. The subscribers are:—

	Shares.
Sir John Pender, K.C.M.G., 18, Arlington-street, London, S.W.	1
Sir James Anderson, 62, Queen's-gate, London, S.W.	1
Thomas Fuller, 13, Chesterfield-street, London, W.	1
Alex. Wood, Abbey Wood, Belvedere, Kent	1
Lord Richard H. Browne, Reigate, Surrey	1
Richard Collett (Secretary to the Brazilian Submarine Telegraph Co.), 50, Old Broad-street, E.C.	1
R. M. Cunningham (Secretary to the Western and Brazilian Telegraph Co.), 19, Great Winchester-street, E.C.....	1

Each of the following companies, The Brazilian Submarine, the Western and Brazilian, and the West Coast of America Telegraph Companies, shall be entitled from time to time to nominate one Director of this Company for each clear number of 2,300 shares of the original capital of this Company, registered in the name of the nominating Company. The number of Directors is not to be less than three, nor more than five. Share qualification £100 (which may be held as the nominee of any other Company). Remuneration as the Company from time to time determine in general meeting.

BOURNEMOUTH ELECTRICITY COMPANY (LIMITED).—Notice has been given that, at the expiration of three months the name of this Company will, unless cause be shown to the contrary, be struck off the Register, and the Company dissolved. This dissolution is, however, subject to the proviso that the liability (if any) of every Director, managing officer, and member of the Company shall continue, and may be enforced as if the Company had not been dissolved.

ELECTRICAL COAL-CUTTING CONTRACT CORPORATION (LIMITED).—A draft agreement has been entered into by the Woodfield Syndicate (Limited) of the one part, and the above-named Corporation of the other, whereby the vendors sell to the Corporation the patents for Great Britain and Ireland, No. 12,676, No. 14,090, No. 16,623 (all of 1887), No. 1,014 (1888), No. 13,369, No. 14,041, No. 19,039 (1889), No. 536 (1890), No. 1,504 and No. 2,664 (1891); and also the benefit of all future improvements in the said inventions to be made by the vendors, and the benefit of all extensions of the terms and privileges belonging to the said patents. The Corporations further acquire the benefit of all licences granted by the vendors for the working of the said patents, and also the benefit of all contracts and negotiations entered into by the vendors for cutting or mining coal by means of the said inventions. The consideration is £202,000, £20,000 in 4,000 fully paid ordinary shares of £5 each, £100,000 in 20,000 deferred shares of £5 each, £7,000 in cash on the completion of the purchase, and the remaining £75,000 by the payment of certain sums according to the shares issued and the profits obtained. As part of the purchase consideration the vendors have the right to subscribe at par for the 2,000 founders' shares of £1 each. The Corporation agree to grant to Messrs. Goolden and Atkinson a licence to use the inventions Nos. 12,676 and 16,623 (1887) and 536 (1891) for other purposes than coal cutting at a royalty of 2½ per cent. on the net value of the machinery manufactured under the said patents. The purchase to be completed before July 1st, and it before that date 10,000 ordinary shares have not been subscribed for and allotted the agreement may be annulled. Particulars relating to the original Woodfield Syndicate are given in *The Electrician* of May 22, 1891.

"LIGHTNING" (LIMITED).—An agreement, made May 23, 1892, between James Whitehead and the above Company, states that it is agreed that James Whitehead shall sell to the Company all his rights and property in the periodical known as *Lightning*, of which he is the sole registered proprietor, and also the book debts and all subscriptions received by him up to December 31, 1891, in consideration of which the Company pays him £800 in cash and £300 in founders' shares of £1 each.

ELECTRICITY SUPPLY CORPORATION (LIMITED).—An agreement made June 9th between the Corporation and Messrs. A. and S. Gatti, states that whereas by a former agreement between the same parties it was determined that in the event of the whole or any part of the shares and debentures of the Corporation, then about to be offered for public subscription not being subscribed for, Messrs. Gatti should procure such a further sum in shares and debentures to be taken up as would enable the Corporation to discharge their indebtedness to them; and in default the Corporation were to allot to Messrs. Gatti such shares or debentures as would, if taken up at par, discharge such indebtedness; and whereas the subscription list closed on June 1, 1892, at which time 4,711 £5 shares and 93 £100 debentures had been subscribed for, it is therefore determined that the Corporation shall allot to Messrs. Gatti 15,289 shares (numbered 10,001 to 25,289 inclusive) and 353 debentures of £100 each, and that the sum of £110,745, payable in respect of the said shares and debentures, shall be retained by Messrs. Gatti on account of the indebtedness of the Corporation to them. Messrs. Gatti also agree to take up or cause to be taken up £25,400 in debentures for the purpose of providing working capital for the Corporation.

LANCASHIRE ELECTRIC AND ENGINEERING COMPANY (LIMITED).—The annual return of this Company, made up to September 27, 1889, was filed on April 13, 1892. Out of a nominal capital of £20,000, in £5 shares, 375 shares had been taken up, and a call of £2 per share made, resulting in the payment of £580, leaving £170 in arrears. The annual return for 1891, made up to June 21st of that year, was also filed on April 13, 1892. The same number of shares had been taken up and £5 per share called and paid. The annual return for the present year, made up to March 15th, was filed on April 13th, the same number of shares being taken up.

R. C. CUTTING, DOUGLASS AND CO. (LIMITED).—A contract, dated June 13, 1892, between Archibald Douglass and the Company, states that whereas the said Archibald Douglass is the sole proprietor of the business of lightning conductor manufacturers and electrical engineers carried on under the name of "R. C. Cutting, Douglass and Co.," at Wardrobe-chambers, Queen Victoria-street, E.C., and whereas the Company had been formed with a capital of £20,000, in £5 shares, with a view to the acquisition and carrying on of the said business, it is therefore agreed that the said Archibald Douglass shall sell the business to the Company, and that the consideration for the said sale shall be satisfied by the allotment to the said Archibald Douglass or his nominees of 1,979 fully-paid shares of £5 each (numbered 8 to 1,986 inclusive).

T. R. HARDING AND SON (LIMITED).—This Company has been registered with a capital of £54,400, in £10 shares, to acquire the undertaking, as a going concern, of a card, comb, steel pin, and counter manufacturer, now carried on at Leeds, Yorkshire, by T. W. Harding, under the style of T. R. Harding and Son, at the Tower Works.

REUTER'S TELEGRAM COMPANY (LIMITED).—The annual return of this Company, made up to the 15th ult., was filed on the 20th. The Company was registered on February 20, 1865, and now has a capital of £100,000, divided into 12,500 shares of £8 each; 10,802 of these have been taken up, the full amount called, and all calls (£86,416) paid.

CITY NOTES, &c.

CALLS DUE.—*July 1st:* Elmore's French Copper Depositing Company (Limited), 60,000 £10 per Cent. Preference shares of £2 each, 10s. *July 5th:* Johannesburg Lighting Company (Limited), Seven per Cent. Mortgage Debenture Bonds of £50 each, £12. 10s.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 26th were £747, as against £697 for the corresponding period of last year, being an increase of £50. The total receipts to date, from January 1st last amount to £20,454, against £19,197 in the corresponding period of 1891, being an increase of £1,257.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company's half-yearly general meeting will take place at Winchester House on Friday, July 22. This Company announce that, subject to final audit, the accounts show, after placing about £68,000 to the reserve fund, a balance available sufficient to pay at the general meeting on July 22nd next, the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the preference shares, less income-tax; and a final payment of 2s. 6d. per

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share with a bonus of 3s. per share, both free of income-tax, on the ordinary shares, making, with previous payments on account, a total distribution of 6½ per cent. on those shares for the year ended March 31st last. The transfer books of the Company will be closed from the 15th to 22nd July, both days inclusive.—The Liverpool office is now K 13, Exchange-buildings, *vice* H 5, Exchange-buildings, Liverpool.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company on Wednesday declared an interim dividend, for the quarter ended March 31st last, of 2s. 6d. per share, free of income-tax, payable on the 15th proximo. The Share Register will be closed from the 7th to the 14th proximo, both days included. The coupon on this Company's Five per Cent. Australian Government Subsidy Debentures, due on July 1st, will be paid on and after that date at Messrs. Barclay, Bevan and Co.'s, 54, Lombard-street, E.C. Coupons must be left three clear days for examination.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS (LIMITED).—The Stock Exchange Committee have ordered the further issue of 8,400 shares, Nos. 41,600 to 50,000, to be quoted in the Official List.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The usual half-yearly meeting of this Company will be held at the offices of the Company, 38, Old Broad-street, E.C., on Tuesday, July 12th.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 24, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,792.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 22.		Price Wednesday, June 29.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 29.	
										Highest.	Lowest.
			TELEGRAPHS					£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	48 49		48 49		5 12 3	Jan., Apr., July, Oct.	48	..
£2,849,510	Stock	25/0	Do. Preferred	87½ 88½		88 89		5 18 0	" "	88⅜	88⅜
£2,849,510	Stock	5/0	Do. Deferred	10¾ 11¼		10¾ 11¼		..	" "	10⅛	10⅛
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101 104		101 104		3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	10¼ 10⅜		10¼ 10⅜		7 8 10	Mar., June, Oct., Dec.	10⅜	10¼
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104		101 104		4 16 2	January and July	102	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	105 109		105 109		4 11 9	June and December	..	..
$7,716,000	$100	8½	Commercial Cable Capital Stock xd	155 160		155 160		4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12		11 12		6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½		16½ 17½		5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3¾		3½ 3¾		6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10%	9 10		9 10		5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅛ 11⅜		11⅜ 11⅝		6 0 2	Jan., Apr., July, Oct.	11⅛	11⅛
400,000	10	2/6	Eastern	14⅝ 15		14⅝ 15		4 6 8	" "	15	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15¾		15½ 15¾		3 16 2	" "	..	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111		108 111		3 12 1	May and November	108¾	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110		108 111		4 10 1	February & August	108¾	..
250,000	10	6/6	Eastern Extension	15 15½		15 15½		4 11 10	Jan., Apr., July, Oct.	15⅞	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111		108 111		4 10 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106		104 107		4 13 6	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105		103 106		4 14 4	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102 105		102 105		3 16 2	February & August	..	..
180,227	10	2/6	Globe Telegraph and Trust	10⅛ 10⅝		10⅛ 10⅜		5 1 2	Jan., Apr., July, Oct.	10⅛	10⅛
180,042	10	6%	Do. 6 per Cent. Preference	15⅛ 15⅝		15⅛ 15⅝		3 18 1	" "	15⅛	15⅛
150,000	10	7/2	Great Northern	18¾ 19¼		18¾ 19¼		4 9 2	Jan., April, and July	19	18⅞
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109		106 109		4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	40 42		40 42		5 19 1	May and November	41½	40½
38,348	10	4/0	London Platino-Brazilian	6 7		6 7		5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109		107 110		5 9 1	March & September	109	..
9,000	8	8/0	Reuter's xd	6½ 7½		7 8		5 0 0	April and October	7¼	7¼
3,381	£100 Cert.	£1½	Submarine Cables Trust 6%	115 120		115 120		5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	7 8		7 8		6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99 102		100 103		4 17 1	March & September	101⅜	101½
30,000	10	2/0	West Coast of America	3½ 4½		3½ 4½		5 11 1	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	104 108		105 109		7 6 10	June and December	..	..
88,321	10	6d.	West India and Panama	1½ 1½		1½ 1½		..	" "	1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10		9½ 10		6 0 0	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9		8 9		6 13 4	" "	..	..
67,007	15	6/0	Western and Brazilian	8¾ 9¼		8¾ 9¼		8 2 6	" "	8⅜	..
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6 6½		6 6½		5 15 3	" "	6⅜	6⅛
30,364	7½	4/6	Do. 5 per Cent. Deferred	2¾ 3½		2¾ 3½		..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105 108		105 108		5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105 108		105 108		5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122		118 122		5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103		100 103		5 16 6	March & September	..	..
			TELEPHONES.								
224,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance xd	⅛ ⅜		⅛ ⅜		6 10 10	May and November	..	..
x20,000	£1	4½d.	Oriental (11s. paid)	1/16 5/16		3/16 5/16		6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛ 5⅛		4⅛ 5⅛		5 17 1	June and December	5⅛	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½ 13¾		13½ 13¾		4 7 3	" "	13¾	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12½ 13		12¾ 13¼		4 10 7	" "	13¼	13
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109 111		109 111		4 1 1	January and July	110¼	109⅜
58,000	5	1/0	United River Plate	1½ 2⅛		1½ 2⅛		..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95		85 95		5 5 3	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	10 10½		10¼ 10⅜		..	..	10½	10⅜
19,900	£5	..	Electricity Supply Co. of Spain	.. ..		.. ..		..	..	..	..
8,332	£5	..	House to House Electric	2⅛ 3⅛		2⅛ 3⅛		..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½ 6		5½ 6		..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 6		5½ 6		..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16		3 7/16 3 9/16		..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16		5 1/16 5 3/16		..	March	..	..
111,000	5	..	London Electric Supply	¾ 1¼		¾ 1¼		..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾ 7¼		6¾ 7¼		..	..	7 1/16	6⅞
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5		4 5		..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8¼ 8¾		8¼ 8¾		..	..	8½	8¼
7,900	£5	7%	Do. 7% Preference	7¾ 8¼		7¾ 8¼		..	..	8¼	..
42,853	5	..	Westminster Electric Supply (fully paid)	6¼ 6¾		6¼ 6¾		..	..	6⅞	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	2⅞ 3⅛		2⅞ 3⅛		..	..	..	..
69,996	2	6%	Do. 6 per Cent. Preference	2 2¼		2⅛ 2⅜		5 1 1	..	2⅛	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6		5½ 6		..	January and July	..	..
17,130	5	17%	Edison and Swan United	.. ..		.. ..		..	—	..	..
45,000	10	12/0	Electric Construction	5¼ 5⅜		5¼ 5⅜		..	—	5⅜	5⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜ 2⅝		2⅜ 2⅝		—	—	2⅜	2⅜
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3		2 3		..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½ 20½		20 21		5 19 1	February & August	20⅞	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106		104 106		4 4 11	March & September	105	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½		3½ 4½		..	..	..	..
11,334	£10	8/0	Do. Preference	8 9		8 9		8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼ 1/16		¼ 1/16		..	..	..	..
78,949	5	2/9⅔	Swan United (£3. 10s. paid)	3½ 3⅝		3¼ 3⅜		10 5 6	May and November	3 1/16	..
36,250	12	36/0	Telegraph Construction and Maintenance	44 46		45 47		5 2 1	March and July	46	45½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106		103 106		4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅛ ¾		⅛ ¾		..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½ 3		2½ 3		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	.. ..		.. ..		..	..	..	..
50,000	£10	—	City and South London Railway	2½ 3½		2½ 3½		—	..	..	..

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THE ELECTRICIAN.

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NOTES.

The event of the week has been the inauguration of the Tivoli supply station. The current is generated by six 350-H.P. Ganz alternators, driven by Pelton water-wheels, with a fall of about 160ft. Each machine gives 45 amperes at 5,000 volts, and this is conveyed to Rome over a distance of about 22 miles by four copper wires. The Via Porta Pia was illuminated by arc lamps on Monday evening. The machinery was started in the presence of the Minister of Public Works, the Minister of Posts and Telegraphs, and many scientific men. Letters of congratulation from several English electricians were read. A description of the plant at Tivoli, and some details of the line, were given in *The Electrician*, Vol. XXVI., p. 608, in the course of Dr. Fleming's articles on "Alternating-Current Electric Supply Stations."

By failing to attend to the most important and practical condition imposed by the Privy Council in the granting of extension of patents, Mr. Lane Fox has been unable to prolong the period over which the payment of royalties may be spread. This, we understand, would have been in Mr. Lane Fox's opinion a convenience to the infringers, but they apparently did not see the matter in the same light.

The details of damage and disaster caused by the severe series of thunderstorms which broke over the country within a few hours of the Dissolution of Parliament would fill two or three of our pages; but though the provincial papers have abounded with descriptions of damage by lightning, no facts have been published from which any new useful or scientific deductions can be made. We notice that on several occasions mantelpieces have been blown out into rooms, a feature to which we have already called attention in these columns. At the Vienna Theatrical Exhibition, the whole of the glow-lamps are said to have been lit up for an instant.

The interesting extension of Thomson's law of maximum economy which is discussed by Mr. Carter in another column suggests that the many laws with which electricians are familiar are capable of application in much wider spheres than even the physical sciences, and in truth pervade all nature and the moral world. Wherever an active force is partially opposed, Ohm's law may be applied. The number of electors who are induced to vote is proportional to a force of persuasion or conviction, divided by laziness or apathy. Ewing's curve of hysteresis lends itself to an elaborate ethical analogy, in which H becomes good or bad influence according to its sign, and the curve tends to asymptotes of virtue or depravity. Thomson's law of economy is really universal, but, depending as it does upon interest on capital for one of its essential factors, it may be often overlooked in these days when capital is said to be an evil, and interest on it (by a peculiar mode of reasoning) a theft from somebody who has nothing whatever to do with it. If, as we are told, the foundations of English philosophy are only now being laid, these laws, under other and broader names, will perhaps someday be recognised as principles of everyday life.

In the account which we publish in another column of the testing of continuous-current transformers, it will be noticed that the same voltmeters and ammeters were used to measure the power supplied and the power developed after double transformation. This was done with a view of eliminating instrument error; but it should be remembered that the only error which is thus eliminated is in such an one as an erroneous constant. If the voltmeter read 1 per cent. too high throughout the scale, or if it read in volts derived from the B.A. ohm instead of a Board of Trade volt, no error would be introduced into the result; but if the scale were improperly graduated, or if the instrument were otherwise an imperfect one, this method of interchange would not ensure a correct result.

Prof. E. J. Houston has thrown the weight of his authority on the question of the physiological effects of alternating currents of high frequency, and has communicated a short statement to the Franklin Institute on this subject. He says that it is well known that the physiological effects of alternating discharges of but moderate frequency are more severe than are those of steady currents of the same strength; but with still more rapid alternations the physiological effect decreases, until, "at extraordinary high frequencies, all harmful physiological effects practically disappear." He refers to the experiments of Dr. Tatum; but high frequencies were not employed by that gentleman. There have been many experiments in which the voltage has been measured with sufficient accuracy, and it is beyond doubt that with a *given voltage* the physiological effect is diminished with high frequencies. But we have never yet seen any record of trustworthy measurement of rapidly alternating currents in

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this investigation. In *The Electrician*, Vol. XXVI., p. 644, an abstract of a Paper by Prof. ELIHU THOMSON on the Physiological Effects of Alternating Currents of High Frequency was published; but not a hint was given about the method of measuring such currents. Dr. TATUM, in his experiments of 1890, used a hot-wire ammeter, an instrument in which complete confidence may be placed, since it may be easily calibrated by continuous currents. But he did not go beyond 800 per second.

IN his recent communication Prof. HOUSTON quoted from a lecture by Mr. TESLA, in which he says that he had found that by using ordinary low frequencies the physiological effects of the current required to maintain at a certain degree of brightness a tube 4ft. long produces powerful shocks, whereas with 20,000 alternations per second the tube may be maintained at the same degree of brightness without any effect being felt. But he goes on immediately afterwards to say that this is due principally to the fact that a much smaller difference of potential is required to produce the same light effect, and also to the higher efficiency in the light production. It is obvious, therefore, that the illumination of a given tube to a given brilliancy is no measure of the current; and we will go so far as to say that this experiment is very misleading, or rather that hasty conclusions from it have misled many people.

PROF. HOUSTON goes on to suggest that what has been called the "skin effect," or concentration of rapidly alternating currents in the exterior of conductors, may account for the harmlessness of such discharges; but this might very probably increase rather than diminish the sensation, since a very large proportion of the endings of sensory nerves are in the skin, though it is true that the current might thus avoid the vital organs. "As the frequency of alternation increases," says Prof. HOUSTON, "the body becomes more and more protected, until, when the frequency becomes as great as that of the ether waves which cause sunlight, they would probably produce on the surface of the body the same genial effects as are produced by the light and heat of the sun, with which they are probably identical." But sunlight kills bacteria, possibly because they, or their vital organs if they have any, are so minute that they feel ether waves as shocks. They are about the right size to vibrate mechanically in syntony with the ether undulations, and perhaps this is very unpleasant.

To measure these rapidly alternating currents is almost impossible with any galvanometer, and we wait for some measurements with hot-wire instruments, or with Prof. JONES' thermo-electric method, before we can admit that the physiological effect of a current of given magnitude becomes insignificant if the frequency be very high. No physiologist has yet explained the relation of the current as truly measured in milliamperes, and of the voltage, in physiological effects, or whether a "sawtooth" current is more painful than a "sine current." Medical men are gradually acquainting themselves with the subject, and we hope that some really scientific information will soon be forthcoming. Professional etiquette, of course, strictly forbids them to send communications to "lay" journals, but we will endeavour to place before our readers the pith of any results which may be published elsewhere.

IN our issue of June 3rd we printed a short article by Mr. CARL HERING, the object of which was to show, if possible, that a current of electricity produced a number of magnetic lines proportional to the product of the strength of the current and the length of its path. Our criticisms on that occasion have called forth an interesting reply from Mr. HERING, but we still maintain the accuracy of the statements which his letter questions. The quantity K, to which Mr. HERING alludes, is not constant even for circular coils of different sizes, unless the diameter of the wire bears a constant ratio to the diameter of the circle, and for straight wires K will similarly vary with the diameter of the conductor. Moreover, in all practical cases, the presence of masses of iron so much affects the result, that the consideration of coils with merely air magnetic circuits is of little value. The chief importance of Mr. HERING'S suggested method of calculation is due to the fact that, although it may lead to erroneous results if applied universally, yet in the chief practical cases where it can be used it will yield results in fair accordance with facts. Even here, however, it must be remembered that the effects of an ampere turn round a good magnetic circuit, such as that of a dynamo, is the same whether the wire closely envelopes the iron or is wound round it at some distance away, so that an ampere-foot of wire is less effective for the outer layers of the field-magnet coils than for the inner ones.

AT 5:45 yesterday (Thursday) evening we learn from New York (by the courtesy of the Anglo-American Telegraph Company) that the serious condition of Mr. CYRUS FIELD remains unchanged, and that the end may be expected at any moment.

Lord Kelvin.—The Academy of Sciences at Berlin has conferred one of the first four Helmholtz gold medals upon Lord Kelvin.

Gotha.—This city is about to adopt the electric light. Electric current is also to be supplied for power purposes and for running a tramway here.

Proposed Electric Lighting of the Vatican.—We learn from *L'Elettricita* that it is proposed to light the whole of the Vatican by means of incandescent lamps.

Pfarrkirchen.—The town of Pfarrkirchen in Lower Bavaria is deliberating upon granting a concession for street and private lighting. Water-power is available.

Turin.—A project is on foot for utilising 5,000 H.P. derived from the river Cenischia for electric lighting at Turin. The transmission will probably be effected on the "drehstrom" system.

British Association.—We are requested to announce that on Monday, August 8th, there will be a discussion in Section A of the British Association on a "National Physical Laboratory," to be opened by Dr. Oliver Lodge.

Telegraph Communication with Gilgit completed.—It is reported from Kashmir that the telegraph line from Skardu to Bunji has been constructed; consequently, telegraphic communication with Gilgit by way of the Zojilo Pass is completed.

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Personal.—Mr. Harry Wilkins, Vestry Clerk of St. James's, who conducted the case of the Vestry at the Electric Lighting Inquiry by Major Marindin in 1889, was called to the bar at the Middle Temple on Wednesday last week.

Proposed Paris Exhibition in 1900.—M. Jules Roche, Minister of Commerce, reported upon the preliminary arrangements for an International Exhibition at Paris in 1900; and in a telegram to *The Times* it is stated that it may now be considered as settled that an Exhibition will be held in that year.

Manx Exhibition.—The Isle of Man Exhibition was opened at Douglas on Monday last by the Governor of the island, in the presence of a large assembly. The buildings have been furnished thoughout with the electric light, supplied by the Brush Electrical Engineering Company.

Paisley.—The Electric Lighting Committee of the Paisley Town Council have obtained tenders from three contractors for high-pressure systems, and three contractors for low-pressure systems, with a view of lighting the compulsory area of supply described in their Provisional Order of last year. The estimates ranged between £22,000 and £33,000.

Chicago Exhibition.—It is intended that the steam machinery at Chicago shall be started on May 1, 1893, by the Marquis de Veragua, a descendant of Columbus. As, however, the Marquis is too old to come to Chicago, he will at a certain hour on the opening day press an electric button in Madrid placed in direct communication by submarine cable with the World's Fair, and by this means will set in motion the steam machinery in Jackson Park.

Institution of Electrical Engineers' Conversazione.—On Friday last week the members of the Institute of Electrical Engineers were received by Prof. and Mrs. Ayrton at the Royal Institute of Painters in Water Colours. About 900 guests were present, the visitors including Prof. Crocker and Mr. W. J. Hammer, of the American Institute of Electrical Engineers. One interesting feature of the occasion was that the Institution this year celebrates its majority.

Nordhausen.—A company is now in course of formation in Berlin having for its object the construction of an electric tramway in Nordhausen, and, further, an electric railway to run *viâ* the Harz to Thale. It is proposed to utilise the water power of the Harz for the generation of electric energy, which will be applied not only to the working of the electric railway, but also to lighting and power purposes in the surrounding districts, conditional upon the necessary permission being obtained from the local authorities.

Budapest.—The Town Council of Budapest, says *Industries*, has definitely resolved to give the concession for the erection of an electric central station to Messrs. Ganz and Co., of that city. The station is to be erected in the Aussere Wartzner Strasse, near the Danube, and about 1¼ miles from the city, and will be on the Zipernowsky-Déri-Blathy transformer system. The plant, which will somewhat resemble that of the International Electricitäts Gesellschaft in that city, will include two alternators of 300 H.P. and 600 H.P. respectively.

Death from Paraffin.—A correspondent writes that it has been estimated that in the United Kingdom alone over 10,000,000 lamps are in use. Mr. Alfred Spencer, of the London County Council, stated at the inquest on the late Lord Romilly that he estimated that there were 300 deaths a year caused in this country by unsafe lamps. Mr. Shean, of the Fire Brigade Association, expressed the opinion that 10 per cent. of fires are caused by paraffin lamps, and Captain Shaw, the former Superintendent of the London Fire Brigade, reported 156 fires in one year caused by the upsetting of lamps in London. It is suggested that there should be a short Act of Parliament compelling every lamp to have affixed to it an automatic extinguisher, as recommended in the reports of Sir Frederick Abel, Mr. Boverton Redwood, and Colonel Majendie.

A Practical Form of Ohm's Law.—An ingenious *memoria technica* has been suggested by Mr. Herbert M. Pilkington, of the Edison Electric Illuminating Company, of Brooklyn, which is shown by the accompanying letters. Every one who has had anything to do with the application of electrical laws has no doubt found it difficult at times to remember even so simple a one as that of Ohm. Of course everyone knows Ohm's law; but somehow, just at the moment when it is most needed, it manages to get twisted around into a state of hopeless confusion. This device is intended as a remedy for all these troubles, and to make the application of the law a matter of the utmost simplicity. The *Electrical World* of New York thinks that the design may be worked up into an appropriate badge that can be worn where it is always at hand; but it might more conveniently, perhaps, be scratched on a vacant spot on a two-foot rule. By merely placing the finger over R one finds $\frac{E}{C}$ staring him in the face. Or, if E is covered, its value C R is plainly seen. Concealing C will bring $\frac{E}{R}$ boldly out.

$$\frac{E}{C R}$$

Telegraphic Statistics.—According to the *Journal Télégraphique*, the European telegraph system comprised 407,080 miles of line at the beginning of 1891. The telegraph mileage for North and South America, the Australian Colonies, and other extra-European countries amounted at the same date to 342,550. Adding to the totals the 145,030 miles of submarine cable, we obtain a grand total of 894,660 miles. The number of telegraph offices open in Europe is 67,465, and outside Europe 31,000; a grand total of 98,465. The number of instruments in use is 101,500 for Europe, and 71,000 for countries outside Europe; a grand total of 172,050. As to telegraphic traffic, the figures relating to it are as below:—

Place.	Number of messages.			Receipts.
	Inland.	International.	Total.	£
European countries	162,996,000	44,599,000	207,595,000	10,210,560
Extra-European countries	75,547,000	12,875,000	88,422,000	10,757,200
	238,543,000	57,474,000	296,017,000	20,967,760

Telephone Statistics.—The following table will be of interest; it is taken from the *Journal Télégraphique*:—

Country.	No. of towns provided with exchanges.	Length of wire in kilometres.	No. of subscribers.	No. of conversations.	Average no. of conversations per diem per subscriber.
Germany ...	260	100,396	59,086	223,852,925	12·6
Italy	*42*	*18,128*	*10,481*	*16,709,000*	*5·*
Japan	2	1,680	560	680,000	4
Austria	42	2,267	1,252	540,000	1·5
„	*11*	*32,511*	*7,659*	*12,437,000*	*5*
Sweden	126	6,722	4,767	8,157,000	5·5
„	*243*	*27,536*	*14,600*	*13,500,000*	*3*
Switzerland..	92	17,067	10,945	5,350,000	4
Luxembourg.	43	343	811	562,000	2·5
Belgium	4	821	199	22,128	0·5
„	*11*	*10,600*	*5,846*	*12 000,000*	*6·5*
Hungary ...	4	3,126	1,540	6,020,000	13
„	*8*	*790*	*641*	*800,000*	*4*
Spain	6	370	70	—	—
„	*29*	*17,504*	*7,022*	*4,200,000*	*2*
Norway	32	*6,545*	*5,110*	*6,000,000*	*4*

The figures printed in italics relate to private companies.

The Ampere Hour.—Some curious definitions of an ampere hour were given in Court during the Lane Fox appeal last week, and are briefly alluded to in our report of the case. The following is an attempt to give rather more fully the general ideas of these definitions:—An ampere hour is not exactly an ampere or an hour, but it closely resembles both, combining their useful qualities and eliminating their incidental drawbacks. Suppose you have an income of £500 a year, then the number of year-pounds, according to or corresponding to the unit of time, gives you the rate of expenditure, and the sum in one hour therefore corresponds to one ampere, and so the amount is an ampere hour. Another very clear illustration may be taken from a stream of water, which flows at so many gallons per minute, the gallons corresponding, of course, to the amperes; so 500 gallon-minutes—that is, ampere hours per gallon, so to speak—is the total quantity or current which

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measures the rate of flow in unit time for each gallon-hour per minute. So one hour flows for each gallon or ampere, and corresponds to an ampere per gallon for each hour. That is an ampere hour.

Electrical Underground Railway for Berlin.—In a Paper by Mr. Holle, in the *Verein für Eisenbahnkunde*, a scheme for a railway closely following the design of the City and South London line is described. The project has been put forward by the Allgemeine Elektricitäts Gesellschaft. The trains, running at three-minute intervals, will be about 1,000 yards apart, and 48 trains, consisting of 48 electromotives and 144 carriages, will be running at once. Two power stations with two complete plants each will be erected, and under ordinary circumstances one engine and dynamo of each station will supply current to one of the cross-lines and half the circle line; but the leads will be so arranged that, if necessary, the whole system can be worked from either of the stations at will. There will be a constant pressure of 500 volts, slow-speed motors with varying resistances, and gearing running in oil to diminish friction and noise. The total length of the line is about 30 miles, with an estimated cost of £2,550,000, or £68,500 per mile. The charge for any distance per passenger will be 1·2d, The traffic is estimated at nearly five persons per carriage-mile, or 57,000,000 passengers per annum, with 11,800,000 carriage-miles, or 177,000,000 passenger-miles. This would bring in a total yearly receipt of £285,000, of which £144,000 would be required to defray running expenses.

Proposed Teaching University for London.—The following letter from Prof. A. W. Rücker appeared in *The Times* of Friday last week :—

Some days ago you published suggestions as to the constitution of the proposed Teaching University for London which have the approval of an association largely composed of those who teach in London colleges.

Their main contention is that the present sporadic attempts at supplying London with teaching of a University type have largely failed, and that the time has come when efforts which have hitherto been isolated and independent should be made in concert.

No better illustration of the validity of this contention could be found than in two paragraphs which are inserted, without reference to each other, in this week's *Electrician*.

In the first place we are told that the Corporation of the City of London has declined to contribute further to the support of the City and Guilds Institute for a "year or two." In the second, that the Council of University College find it necessary to increase their electrical laboratories, but are unable to supply the necessary apparatus, and are therefore about to send the hat round.

I do not propose to criticise the action of the Corporation, and I sincerely hope that the appeal of the Council of University College will meet with a ready response. But it is time that the question was clearly put to Londoners, Do they think that this sort of thing is worthy of the capital of the British Empire? The classes at the City and Guilds Institute are most successful; yet the Corporation, which helped to start them, now withdraws support when they are in mid career. Meanwhile, what is practically a rival institution in Gower-street can barely make both ends meet, and is hampered at every step by want of funds.

Could any better proof be desired that independent and competing colleges working in the same town can only obtain from municipal bodies and individuals intermittent, uncertain, and insufficient support?

If London is to have an adequate teaching University it can only be by establishing it on a basis so wide and so strong that individuals, corporations, and State departments shall take the same pride in it that we all take in the British Museum or the National Gallery. This can only be accomplished by a fusion of interests. Those who care more for the advancement of learning and the spread of knowledge than for the machinery by which London has tried, with very partial success, to provide for them in the past cannot be too strongly warned that if we let slip the present opportunity of replacing what is already antiquated by one powerful engine for good, another half-century of ineffective effort may be before us.

Electric Lighting Statistics for Paris.—Four companies are at present engaged in the supply of electricity to the Parisian public, viz., the Compagnie Continentale Edison, the Société Parisienne d'Éclairage et de Force par l'Électricité, M. Popp, and the Société d'Éclairage Électrique du Secteur de la Place Clichy. These four concessionnaires had, of course, to agree to the conditions imposed by the Municipality. Clause 16 of the *cahier des charges* runs as follows:—The grantee will pay the town quarterly during the whole period of its concession—(i.) A rental of 100fr. per annum for each kilometre or fraction of a kilometre length of conduit laid in the sewers or under the pavements; (ii.) Five per cent. of the output for light and power purposes, as ascertained either by the amount of the contracts or by the indications of the meters. In the Budget for the present year the following figures are to be found :—

Ascertained receipts in 1890	Fr. 86,353
Receipts which appeared in the 1891 Budget	Fr.160,000
Estimated receipts for 1892	Fr.318,000

The basis for the estimated receipts for the current year is as follows :—

Concessionnaires.	Kilometric tax (francs).	5% of gross receipts (francs).
Compagnie Continentale Edison	3,200	100,000
Société Parisienne	3,200	100,000
Popp	8,200	50,000
Société de la Place Clichy	3,500	50,000
Total	18,100	300,000

From these items we see that by December 31st next some 181 kilometres, or 112¼ miles, of underground electric mains will have been laid in Paris, and that the gross income of the four Parisian electricity supply companies will probably amount to six million francs, or £240,000. Taking the price of the kilowatt-hour at 1fr., the total estimated output is therefore 6,000,000 kilowatt-hours, which would suffice for about 250,000 8-c.p. 32 watt lamps connected.

Electrical Sub-stations.—In ordinary life conventionality, says *Industries*, is a boon to the majority, because it saves them the trouble of deciding for themselves on nearly all their ordinary actions; but it is a kind of bondage to the thinking man, who is apt to decide things for himself on their merits. He frequently goes wrong, but all progress is due to him alone, all the same. And so it is in electrical engineering. Fashion provides the less competent with a convenient mantle, but it prevents rapid development. Though some of our consulting engineers are men of first-rate ability, the remainder are scarcely capable of developing such things as new schemes of electrical distribution. The small transformers in houses are almost universally supposed to have all-day efficiencies of something well over 90 per cent.; but, though it is well known that, other things being equal, a large transformer is much more efficient than a small one, all kinds of mechanisms are devised for cutting sub-station transformers in and out. That is to say, the greatest attention is given to the cutting in and out in the particular case when it is least necessary. Gas engines with water gas can be made to work with about 1½lb. of coal per horse-power hour. They can be started in a few seconds when required, they need little attendance, and require no boilers and very little labour in connection with the gas producer. It may be said there are no large gas engines. When central stations were first started there were no special steam engines for the work. A few inquiries received by one or two leading gas engine makers would soon lead to the production of large power high-speed machinery. When the gas-engine comes into use the secondary battery will disappear from central stations, and will retire to private houses, or to electric tramcars. In these future days there will also be alternating motors. Whether there will be any customers who want them is another matter, but their existence will silence the cry that direct currents must be employed because of the enormous demand for motive power. There is no law of nature according to which alternating currents must be distributed at 2,000 volts. This is also a fashion; and having regard to the extra cost of insulation it would in many cases be preferable to use much lower pressures. The larger portion of the power will be supplied direct at 200 volts plus the loss in the feeders. The distant parts will alone require transformers and high-pressure feeders. The alternating-current advocate seems unable, however, even to think of a low-pressure system. If he had to supply current to a theatre next door to his station he would no doubt do it at 2,000 volts. To recapitulate, we would suggest that sub-stations with dynamotors ought not to exist, and that an alternating distribution should be used, coupled with batteries or not. Further, that in alternating systems sub-stations should be superseded by feeder transformers, and that banking transformers in sub-stations with automatic switches is unnecessary, and will probably lead to breakdowns and failures.

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COMMUTATORS.—I.

BY F. M. WEYMOUTH.

That part of a dynamo which may be said to be next in importance to the armature and magnets is the commutator, or collector, as it is variously termed. For it is here that the current, after having been generated in the armature, is finally collected; and it is from and to this part that it is led away through the outer circuit of lamps and so forth, and brought back again for the renewal of lost energy or potential. On returning into the commutator at one side at minimum potential, the current courses through the armature, and is delivered again at the opposite side of the commutator *changed* to a current of maximum potential: hence the term "commutator," from the Latin *commuto*, to change, or alter entirely.

The object of these present articles, more especially for the benefit of the younger readers, or those to whom electrical work may be new but who may otherwise have had good practical training and experience, is now to consider some of the various forms of commutator that have been brought out; and also some of the points that have to be kept in view when getting out the design for this portion of a dynamo, such as have led more or less to those differences of form to which we allude.

Without pretending that a commutator is to any very great extent intrinsically complicated, it yet would be a mistake to suppose that a design may be just "knocked off out of hand" without much thought. As great an amount of consideration within reason is required in designing a commutator as any other active part of a machine. For we shall find in the course of our investigation, that as in all designing, from that of an ironclad downwards, there are conflicting requirements to be dealt with, both small and great. To these, therefore, and other collateral considerations, we purpose first to give our attention, before viewing any special examples in particular; our remarks, moreover, must be premised by mentioning that we confine ourselves to commutators for close-coiled continuous-current machines, such as those having drum, Gramme, or flat-ring armatures.

As is well known, the essential principle in the construction of a commutator is that of a series of segmental bars, held together on a substructure, insulated therefrom and from one another. This, omitting substructure, is illustrated in Figs. 1 and 2, the upper half of the latter being in section, so as to afford a full side view of one segment. The shoulder *a* represents the lug whereby connection is made with the armature winding, and through which the current runs either way between the winding and the segment. The thick black lines represent insulation. Now it is obviously the first consideration that each bar shall be large enough to carry the whole current without undue heating, and shall continue so after a reasonable amount of wear. It must be of sufficient thickness and depth, and have length enough to allow of a proper number of brushes to take the current off. But another consideration immediately follows, in respect of economy, inasmuch as the segments are usually of either copper, phosphor-bronze, or gun-metal, all of which are expensive materials. Hence, with regard to prime cost alone, it is not desirable to increase the dimensions over much either way. Again, as to the length, this dimension affects the length of the machine as a whole—in particular as to shaft and bedplate. This increases the total weight, and adds to the prime cost in respect of cast iron and steel. The diameter of the shaft would need increasing in due proportion. It also, however, means greater floor-space, or, on board ship, deck room. In the latter case especially, where space is limited, if one over-all dimension can be reduced without adding to another, there is an object in doing so. But this, it will be seen at once, is directly opposed to the already mentioned necessary condition, that there shall be a sufficient length of commutator for the brushes. We shall see later on, when dealing with particular designs, what methods have been adopted to meet this combination of requirements.

Now, the segments, besides being liable to wear from the constant rubbing of the brushes, are also liable to burn away from sparking between them and the brushes, especially if the sparking is such as flies from them to the brushes. This evil, however, is less liable to arise when the commutator is divided into many segments in proportion to the voltage than into a few. A commutator of many segments is thus for this reason desirable; and for the further reason that it would give a steadier current at any given speed, than one with fewer parts. This question, however, is one with which the arrangement of the armature winding as a whole is concerned, inasmuch as there are the same number of segments in a commutator as there are sections in the winding. Now, with an armature wound in many sections for a high potential and a small current, the bars need not be of large section; yet they must be of appreciable size. But especially owing to the number of bars all requiring to be separated by insulation, this latter material, by its accumulation, forms a considerable factor in determining the diameter. Hence it comes about that the commutator will be of large diameter, sometimes nearly equalling that of the armature itself. But there being only a small current to be taken off by the brushes, the bars do not require to be long, and the commutator will be short in proportion to the diameter. It is obvious, however, on the other hand, that with any given speed, and greater consequent peripheral velocity, there will be more wear of both brushes and segments, and greater consumption of energy, due to the friction of the brushes, with a large diameter than a small. But with a low potential, and large current, and small number of segments, the total amount of insulation between the bars will be reduced in proportion, while the length will need to be greater to accommodate those brushes. Hence the length of the commutator will be greater as compared with the diameter, and the latter considerably

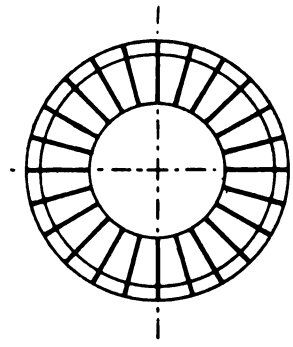

FIG. 1.

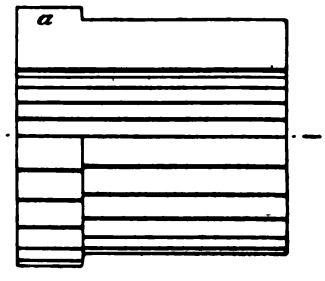

FIG. 2.

less than that of the armature. The thickness of the brushes may, however, be a factor in this question. It is obvious that with any given number of segments the same peripheral brush contact surface subtending any given angle at the centre may be obtained by either having a long thin brush contact surface on a small diameter of commutator, or else a short broad one on a large diameter. Though it is a common feature in small high-tension machines to see the commutator nearly as large in diameter as the armature, a peculiar instance where it is so in the case of a large machine is that of the Elwell-Parker continuous-current transformer, or motor-generator, now on view at the Crystal Palace, and illustrated and described in *The Electrician* for February 26, 1892. Here there are two commutators, one at each end. That receiving the high-tension current for the "motor" function of the machine is composed of a large number of small segments, and the total diameter is nearly equal to that of the armature; while at the same time the length is only a small fraction of the diameter. The other commutator, dealing with the low-potential large current, the outcome of the "generating" function of the machine, has many fewer segments, and is of smaller diameter; while the length is greater than that of the other commutator. Its length is about the same as its diameter, in fact, and a large brush contact surface results. The contact surface being proportional to the current, and not to the potential, much smaller brushes are sufficient on the other commutator.

Returning once more to the subject of sparking and the winding of the armature, it is very necessary that this latter

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be wound or laid on with symmetry and good workmanship, to reduce this evil generally and the secondary effect of the formation of flats in particular. With regard to drum armature winding, it may, perhaps, be mentioned here that a series of articles on this subject may be found in *The Electrician*, commencing November 7, 1890; also an elementary article on the generation of potential and current in drum winding in *The Electrician* for July 19, 1889, for those readers to whom this matter may still present difficulties. Though sparking has not much to do directly with the form of construction of a commutator, yet as a collateral subject it is so intimately connected that it would seem at least reasonable to touch on it a little fully. Such was, indeed, our original intention. But as at the very first subsequent consideration this has shown itself so expansive a topic to deal with, it has seemed better to leave it for a separate article. The principal bearing this matter has directly on commutator construction, already alluded to, is that it should be subdivided as much as possible. The tendency to spark is thus minimised. But, as will be seen, much subdivision increases the total amount of mica between the bars, and consequently the diameter also. Hence a compromise has to be effected, or at least too much subdivision avoided.

A peculiarity, however, in the wear of the segments, apart from their burning, is that, with wire brushes especially, annular grooves are apt to be cut round the commutator. This is mitigated by allowing the armature a slight end play in the bearings when possible. To equalise the wear also, it is usual to adjust the brushes, when there are more than one in a set, so that the gaps between those in one set do not come opposite the gaps in the other set. For the further reduction of wear and cutting it is commonly the practice to put a very little vaseline on the commutator. This is more necessary, however, when the bars are of soft copper or other metal. When of good hard metal, and with stencil-plate or gauze brushes, it appears to cause no detriment to run dry, without any lubrication. Though under certain circumstances some oils may act as perfect insulators, better even than air, it is not desirable to let the oil from the bearings creep over or into the commutator. With large difference of potential between the segments and the parts of the machine at zero potential, a streak of oil between would carbonise; and carbon being a conductor, a short circuit would be set up, leading to leakage. To prevent this, among other reasons, a ridge is generally turned on the shaft, or on one of the nuts retaining the commutator, or elsewhere, from which the waste oil from the bearing is flung off, and is caught by an overhanging annular hood, or oil-catcher, projecting from the bearing, from which it is drained away.

As to the metal used for the segments, besides the gunmetal, phosphor-bronze or copper already mentioned, iron is sometimes used. The prevailing tendency is perhaps towards copper, though this somewhat depends on the form of the segment. Copper segments may either be cast, which can be done by alloying with a little silver—a method adopted by Messrs. Crompton and Co.—or else they can be rolled to the required segmental section and so be cut off in lengths. This metal is, of course, a better conductor than either phosphor-bronze, or gunmetal, or iron. The copper, when not cast, may be either hard rolled or else annealed. The former would be more durable; but the latter is better as regards conductivity. As, however, the ratio of the specific resistances of hard-drawn and annealed copper is given only as 1,652 to 1,615, this seems so slight in proportion that the question of durability would have more weight, and so the hard copper be preferable.

In the process of construction, these bars are filed, or otherwise worked up true, on their flat sides; then, with thin sheets of mica, usually about one thirty-second of an inch thick, and shellac or other varnish between them, they are all clamped together so as to form a hollow cylinder, as shown in Figs. 1 and 2. According to varying practice, the inside may or may not be bored. But while still clamped together they are put in the lathe, and the ends carefully turned to gauge. The substructure consists of a sleeve or bush, usually of gunmetal, though sometimes when large of cast iron. Over this the cylinder of segments is fitted with insulation between, and fastened on by a nut and washer. These latter are either wrought iron or gunmetal, or may be of steel. The whole now forming a compact structure by itself, the clamps are removed. Put in the lathe once more, the outside is carefully turned to a smooth bright surface. Though we shall deal with variations later on, commutators of this general type such as we are discussing have thus this characteristic in common, that when once built they are complete in themselves, and as such can be put on or off the shaft of the dynamo.

(To be continued.)

ARC LAMPS.*

The steadiness of the light is dependent both upon the efficiency of the mechanism of the lamp, by means of which the carbons are fed together, which must be exactly at the same rate that they are consumed; and on the quality and homogeneous nature of the carbons used. The amount of light depends upon the rate at which energy is transformed at the arc into heat and light.

Efficiency.

The power or number of watts utilised in the arc is always less than the total amount supplied to the lamp, part being used in electro-magnets or solenoids for operating the mechanism, and part being lost owing to the resistance of the carbons.

If W = total power supplied at terminals of lamp,
w = power used in arc,
C = current between lamp terminals,
C_1 = current in series coils,
C_2 = current in shunt coils,
E = potential difference between lamp terminals,
e = potential difference of arc,
R = resistance of carbons,
R_1 = controlling resistance for parallel lamps,
r_1 = resistance of series coils,
r_2 = resistance of shunt coils;

Series Lamp.—Watts lost in series coils $= C_1^2 r_1$,
" " shunt " $= C_2^2 r^2$,
" " carbons $= C_1^2 R$.

$w = e C_1$,
$W = E C$;

$$\text{Efficiency} = \frac{w}{W} = \frac{e C_1}{E C} = \frac{e C_1}{C_1^2 (R + r_1) + C_2^2 r_2 + e C_1}$$

Parallel Lamp.—Watts lost in series coils $= C^2 r_1$.
" " carbons $= C^2 R$.
" " controlling resistance $= C^2 R_1$.

$w = e C$,
$W = E C$.

$$\text{Efficiency} = \frac{w}{W} = \frac{e C}{E C} = \frac{e C}{C^2 (R + r_1 + R_1) + e C}.$$

e and E may be easily determined by use of a voltmeter.

Resistance.

The resistance of carbons, 11 to 15mm. diameter, plain, varies from 0·15 to 0·2 ohm per foot, or, if coated metallically, 0·001 to 0·09 ohm per foot. Cored carbons have a higher resistance than solid carbons. The combined resistance of the carbons of a 50-lamp series circuit (10 amperes) may be 25 ohms greater, or require 250 volts more when newly trimmed than when the carbons are nearly used up.

Resistance of the series coils differs in different lamps. It may be 0·05 to 0·2 ohm and that of the shunt coils 200 to 500 ohms.

Resistance of the arc is made up of two factors, one the overcoming of the back E.M.F. which is constant, the other the resistance of the arc or flame itself. The back E.M.F. is due to the energy required to volatilise the carbon, and for

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continuous currents is generally about 39 volts; with very short arcs and large carbons it may be as low as 25 volts. The total E.M.F. of the arc may be expressed as $E = e + b\,L$, where e is the back E.M.F. of the arc, b a co-efficient, and L the length of the arc. If L is in millimetres and $e = 39$ volts, then E may be $= 39 + 1{\cdot}8\,L$.

The resistance of normal arcs of 4 amperes may be about 11 ohms; 10 amperes, about 4·5 ohms; and 100 amperes, about 0·45 ohm. The difference of potential of the arc does not appear to increase with the current density, which may be partly due to the increased sectional area of the arc itself, and partly to the increased conductivity of the arc due to the resulting higher temperature.

Beiblätter says for an arc burning silently the E.M.F. is 39 volts, and when hissing 15 volts. No difference is noticeable whether the upper or lower carbon is the positive one. Mixing borax and soda, &c., with the carbon, reduces the E.M.F. to 9 or 10 volts. Intense heating of the positive carbon, produced by surrounding it with a fire-clay jacket, increases the E.M.F. to 47 volts silent, and 21 volts hissing. Cooling the upper carbon by a current of water reduces the E.M.F. to 12 and 5 volts respectively.

Heat developed by Arc.

If H = heat in gramme Centigrade degrees,
E = potential difference of arc in volts,
C = current in amperes,
T = time in seconds;

$$H = {\cdot}24\,E\,C\,T.$$

The temperature of the light-emitting surface of the carbon is that of the volatilisation point of carbon, and is therefore constant, and cannot be raised above that point under ordinary atmospheric pressure. Dewar gives the temperature of the arc at 6,000°C, that is, thrice the temperature of the oxy-hydrogen flame. Rosetti found the positive carbon 3,200°C., and the negative carbon 2,500°C. The temperature of the sun is given as 10,000°C., Rosetti; 250,000°F., Secchi; 4,000,000 to 5,000,00 °F., Ericsson.

The carbon within the crater is in a plastic condition due to the high temperature. The larger the current the greater the light given per unit of power.

Hissing, sputtering, flaming, and general unsteadiness are defects in the arc. Hissing is due to too short an arc, or to use of a carbon with too coarse a grain. Sputtering may arise from impurities in the carbons. Flaming is due to too long an arc, or impurity or insufficient baking of the carbon.

Carbons of too large a diameter, as are sometimes used to prolong the hours of burning, reduce the candle-power obtained per unit of power, and the same applies to the use of very hard and dense carbons. For arcs below 5 amperes the carbons are too small for use in practice, and very large current arcs are difficult to regulate owing to their instability. Soft-cored carbons locate the arc centrally, and give steadier lighting than solid carbons.

With 10 amperes the separation of carbons varies from $\frac{1}{16}$ to $\frac{1}{10}$in. or more. Smaller currents require less separation, larger currents more.

Parallel Working.

For parallel working there should be 60 volts available at least, but 65 volts gives better results, and as much as 70 volts is used in some cases. For a 10-ampere lamp, where the arc requires say 45 volts and the regulating mechanism and carbons 5 volts, this controlling resistance must account for 15 volts, or have a resistance of 1·5 ohms when 65 volts is used. For a 5-ampere lamp it would be 3 ohms, and for a 15-ampere lamp 0·75 ohm. This resistance may be made up of one or more coils of platinoid wire; iron wire is objectionable, owing to its high temperature coefficient.

When lamps are run in parallel with alternating currents the controlling resistance is replaced by an impedance coil, and 50 volts (effective) is sufficient, the arc requiring from 35 to 40 volts only, while the impedance coil has a greater steadying effect than a simple resistance. Thus for the same expenditure of energy a larger current may be used in alternate parallel working, in fact, 13 amperes alternating represents the same energy, viz., 650 watts, as in 10 amperes continuous arcs. It is to be remembered, however, that while the majority of the light in continuous arcs is thrown downwards from the crater, with alternate arcs it it is not. Reflectors should, if possible, be used with alternate arcs. The metallic parts of the solenoids or magnets for alternating lamps must be carefully laminated.

Candle-Power.

The candle-power of arc lamps varies according to the angle at which the measurement is made. The maximum is obtained at an angle of 40deg. to 60deg with the horizontal, and opposite to the positive or top carbon with continuous currents. The horizontal intensity is less than half of the maximum, which, under the most favourable circumstances, without passing through a globe, may be 2,000 c.p. for a current of 10 amperes, using 11-mm. carbons, and the horizontal light in that case would be less than 1,000 c.p.

If S = mean spherical intensity of light,
H = horizontal " "
M = maximum " "

$$S = \frac{H}{2} + \frac{M}{4}.$$

A well-formed crater with the arc or flame confined thereto is the desideratum. With very long arcs the crater disappears, and the ends become rounded. The light emitted from the vapour or flame is comparatively feeble.

Arc lamps (15 amperes) used in the streets of Berlin give 500 to 650 effective candle-power with globes on; they are placed 26ft. 8in. high and 137ft. apart. The light necessary for reading, viz., 10 candles at 40in., is obtained at a distance of 53ft. from the lamp, and in the intervals 4½ candles at 40in. is obtained.

Globes of clear glass absorb 10 to 20 per cent. of light; ground glass, 30 to 40 per cent.; heavily ground glass, 40 to 50 per cent.; and heavy opal glass, 50 to 60 per cent.

Duration and Composition of Carbons.

Lasting power of carbons for a current of given strength varies directly as the diameter. When top and bottom carbons are of same diameter the + wears about twice as fast as the −. With 10 amperes, using 11-mm. carbons, 1 foot of + and 6in. of −, carbon, including allowance for waste, should last 8 hours. Large carbons have more lasting power, and give steadier but less light per watt. Small carbons give more light per watt, but burn away quicker, while the crater is not good. The crater reflects most light when the axis of − carbon is in line with edge of the + carbon. In projectors or search-lamps the carbons are thus arranged:—

Sizes of Carbons Recommended for Various Currents using Cored Top and Solid Bottom Carbons.

Current in amperes.	Diameter of cored positives.	Diameter of solid negatives.
	m/m.	m/m.
5 and 6.	9	9
8	11	9
10	13	11
15	15	13
20	18	15
30	20	18
50	25	20
80	30	25
100	35	30
140	42	35
170	50	42
200	60	50

Carré's carbons are made of pure coke finely powdered, 15 parts; calcined lamp black, 5 parts; special syrup, 7 to 8 parts; the mixture is well combined, and 1 to 3 parts of water are added, and the paste is forced through a die by pressure, and baked in a crucible under a layer of powdered coke and sand.

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THOMSON'S LAW OF ECONOMY.

BY E. T. CARTER.

Every electrical engineer is familiar with the law of economy in electric power conductors enunciated by Lord Kelvin, and known as Thomson's law. By means of it the best section to give any cable can be calculated, the extra cost involved by the addition of another pound of copper and the saving of power caused by its addition being all the data necessary to the calculation. It is not, perhaps, so generally known that this law is much more far-reaching in its influence than is involved in its special application to power cables. Not only in the cable, not only for electric power, but wherever power is transmitted or transformed this same law of economy is in operation. Apart from questions of strength, successful design of every form of engineering machinery depends upon the proper recognition of the relationship—the antagonism, as it were—between prime cost and working costs which is expressed by the terms of this law. If we diminish the prime cost we must expect to get an increase in the working costs; and there is a particular value for the prime cost, at which the annual expenses, together with the interest on the prime cost, will be a minimum. Such is the law; and it is eminently a shareholder's law. No engineer can afford to disregard it; but, whether he is designing dynamos and motors, turbines and waterwheels, or steam engines and boilers, he must take it into account.

With electric power cables we have accurate data enabling us to put the law into exact mathematical form; but in many cases the coefficients are wanting, and only a general application of the principle is possible. Yet experience supplies what abstract mathematics is unable to afford, and indicates the most economical conditions in each particular design. With experience, however, a more elastic range of practice is found than would be permitted by an exact knowledge of the coefficients in each case. Let us glance at some of the instances in which an electrical engineer is concerned with the operation of this law. To begin with, it enters into the consideration of the size of the boiler plant, with the flues and chimney attached to it. If we spend more money on bricks and labour and put up a higher chimney, we shall increase the furnace draught and burn more fuel on each square foot of grate. A higher temperature in the earlier parts of the flues results, and a corresponding improvement in the evaporative efficiency. The annual coal bill is reduced by the extra few feet of chimney. But there is a limit to this practice, beyond which it ceases to be economical; for the extra load of bricks and the labour of building it become more expensive than the coal which is saved, while the increased furnace temperature results in more rapid deterioration of the boiler plates. Experience has fixed the economical limit to the height of the chimney for any given size and type of boiler plant. Again, by allowing the furnace gases to escape at a higher temperature, we can get along with a shorter and cheaper chimney without reducing the draught. The boilers will require less heating surface per horse-power, and will therefore be smaller and contain less metal. This economy in the chimney, the boilers and the space for the boilers to stand on, is met by an increase in the working costs; for more heat is thrown up the chimney, the evaporative efficiency of the fuel is lowered, and the coal bill swells to alarming dimensions. There is a particular temperature at which it is most economical to send the gases up the chimney, and long experience has shown that if no economiser is used the gases should escape at about 600° F., while if an economiser is employed we may cool them to about 400° F. Whether we use an economiser or not should be determined by similar considerations. The cost of the economiser, and of the extra feet of chimney it will involve on account of its flue friction, must be set off against the saving in fuel and the reduction in boiler depreciation and repairs—owing to hot-feed—which it involves. In either case it is found to be false economy to reduce the boiler-heating surface below 3½ sq. ft. for each pound of coal burned per hour, when chimney draught is used.

The boiler steam pressure is regulated by this law, *i.e.*, there is a limit beyond which an increase of pressure is actually wasteful. With increased pressure the efficiency of the steam engine is increased, but that of a given type of boiler is lowered, while the prime cost of both is increased. For, with higher pressures, thicker boiler plates are necessary for both internal and external heating surfaces, and the thermal conductivity of these surfaces is lowered. Either, therefore, the heating surface must be very much increased, making the boiler more expensive, or the efficiency will be very much reduced. In the steam engine a higher pressure involves a higher ratio of expansion if the steam is to be used economically; and this cannot be carried out in one cylinder beyond a certain limit, without cancelling its advantage by the rapid liquefaction which occurs at every stroke. High pressures therefore involve compound, triple and quadruple expansion engines, which are primarily more expensive, per horse-power, than single cylinder engines.

Similar conflicting conditions regulate the point of cut-off, and the piston speed of single cylinder or other engines. If we permit an earlier cut-off of steam we shall, up to a certain point, increase the economy of the engine; but we shall also diminish the work done at each stroke, rendering it necessary to build a larger engine in order to get the same horse-power as before. We do not, therefore, set our engines to work at the highest practicable ratio of expansion when they are doing their ordinary load, but at some lower ratio; thus sacrificing a small increment in steam economy in order that the size and cost of the engine may not be inordinately large. An engine supplied with steam at 60lb., and working with a condenser pressure of 5lb., could, if steam-jacketed, work at a ratio of expansion of from 6 to 8 without serious liquefaction. But it would not pay to set the valves at such an early point of cut-off for the ordinary load, for the horse-power would be so low that the prime cost per horse-power would be much too high a figure. We may attempt to reduce the size and cost of the engine by increasing the piston speed, thus allowing of an earlier cut-off by means of a greater number of strokes per minute. For it is evident that if an earlier cut-off reduces the work of each stroke the horse-power may be kept up to its former value by increasing the number of strokes per minute. The prime cost economy of high-speed engines is to be set off against three sources of increased working cost, thus fixing the limit to economical high speeds. Firstly, with rapid expansion there is excessive liquefaction in the cylinder. Steam expanded rapidly expands almost adiabatically, the jacket having little or no time to supply heat to the cylinder steam. Now, the adiabatic expansion of a saturated vapour is necessarily accompanied with partial liquefaction of that vapour, some of it giving up its latent heat in order that the rest may remain saturated while work is being done on the piston. It is unnecessary to enlarge on the fact that liquefaction in the cylinder is both wasteful and troublesome; and most of the re-evaporation that does take place usually occurs in the back stroke, where it causes a wasteful rise in the back pressure. Secondly, increased piston speed causes increased loss of power, owing to the friction at piston rings, glands, &c. Thirdly, it is more than probable that high piston speeds involve a high rate of depreciation of the machinery; and this is more especially the case where the stroke is short and a high piston speed is produced by a large number of revolutions per minute. Against these considerations, however, the electrical engineer must set off the fact that with high-speed engines, making a large number of revolutions per minute, no wasteful and expensive intermediate gearing is necessary in order that they may run high-speed dynamos. It is probable that a better solution of the problem would be found in the abandonment of high-speed dynamos, *i.e.*, by the substitution of dynamos in which a high peripheral speed of the conductors on the armature is obtained without a very great number of revolutions per minute. The economy of material in dynamos is not a question of a high rate of revolution of the armature, but of high linear velocity of the armature conductors.

These few illustrations may serve to show the importance of the law of economy as a law of engineering design. A little consideration will enable one to see that the question whether one shall add another pound of copper to the cable or dynamo, another load of bricks to the chimney, another cwt. of cast-

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iron to the engine, or another foot to the diameter of the waterwheel or turbine, is, as far as economical considerations are concerned, determined by the opposite consideration, whether the cost of the addition will exceed the capital value of the saving in annual expenses. In other words, *the most economical design in any case is that in which the annual interest on the cost of a small increment of material is just equal to the saving in annual expenses which would result from that small increment.*

It must not be forgotten, however, that economy is not the only consideration. If copper were very much dearer than at present, and coal very much cheaper, the economical current density for a power cable, as given by Thomson's law, would be sufficient to make the conductor dangerously hot and perhaps to fuse it. In every case, therefore, the question of economy must be modified by the essential questions of strength and safety. Consistently with the maintenance of a high factor of safety, there are few problems in engineering which cannot be settled on the basis of this law.

THE ELECTRIC LIGHT INSTALLATION RULES OF THE CHAMBRE SYNDICALE DES INDUSTRIES ELECTRIQUES.

This latest addition to the numerous rules which have been issued for the guidance of contractors retains several useless regulations and one or two very vaguely worded ones. We publish it rather to show what is being done on the Continent than as an example of a valuable set of rules. The old-fashioned rule No. 1 is a relic of the days when fall of volts was not specified. The minimum conductivity is low enough indeed; but we cannot see why a contractor should not use bronze or iron wire if he likes, so long as he does not introduce more than a 2 or 3 per cent. drop.

I.—*Quality of Material.*

1. All wires and cables to be of copper, having a conductivity of at least 90 per cent. of that of pure copper.*

2. Their section must be determined by the condition that the fall of volts between the service box and the most distant lamp is not to exceed 3 per cent. of the voltage at the service box. They are, moreover, to be of such a size that the accidental passage of double the normal current shall not warm them up more than 40°C. This result will in general be obtained if the current density does not exceed

3	amperes	per	sq. mm.	for wires of	1 to 5	sq. mm.
2	,,	,,	,,	,,	5 to 20	,,
1	,,	,,	,,	,,	over 50	,,

Finally, no conductor is to be employed of which the core consists of a single wire having a diameter less than 0·9mm.†

3. The use of bare wires, forbidden as a rule, may be allowed in special cases. Whatever the nature of the location may be, either the insulating coating of the wire or the mechanical protecting sheath must be impervious.

4. Insulation must be obtained by one or more layers of non-conducting materials placed directly upon the copper core. This covering must be sufficiently strong to stand handling when being installed.

5. *Mechanical Protection.*—As a general rule wires are always to be provided with mechanical protection independent of their insulating covering. If conductors are laid along walls in damp places, the mechanical protection must be impervious. Wood casing may be used in dry places. The casing must be of dry wood, and provided with covers. When wires are allowed to remain open to view in dry places, which must as much as possible only be the case when they are beyond reach, they must be protected by ribbon, braiding, or some other covering independent of the insulating material.

6. *Switches.*—The material composing the bases of switches must be appropriate to the nature of the locality. Switches must make good contact, and must not heat when the current is passing. When the breaking of the circuit may give rise to an appreciable arc, for instance, 5 amperes at 100 volts, the apparatus must not remain in an intermediate position, and its base must be of incombustible and unbreakable material.

7. *Cut-outs and Fuses.*—Cut-outs must be arranged so that the fusing of a plug will not give rise to a short circuit. Fuses must be easy to replace, and not give rise to any spluttering of molten metal. They must be clearly marked with a number representing the normal current for which they are intended. They should fuse for a current equal at the most to three times the normal.

8. *Arc Lamps.*—Arc lamps are always to be provided with a covering and a cinder holder. Lamps exposed to the weather are to have their terminals well protected from the rain and from blows. Rheostats are to be mounted on incombustible non-hygroscopic bases. Wires are to be such as not to exceed a temperature of 200°C. under normal conditions of working.

II.—*Conditions for Laying Down Installations.*

9. *Conductors.*—Casings which serve as a mechanical protection to the conductors should not exhibit any discontinuity at joints or sharp angles. Conductors are only to be kept in them by means of the cover. Two wires are not to be laid in the same groove. When crossing gas pipes there must be additional insulation and mechanical protection. When passing through walls and ceilings, the mechanical protection should preferably take the shape of a hard tube with rounded angles. If this tube is metallic a supplementary insulating sheath should surround the wire and project beyond the ends of the tube. When separate conductors are visible they must be at least one centimetre apart, and fixed, so as to keep this distance.

10. *Double Wires.*—Double conductors having within one and the same braiding or covering two separately insulated wires may be used; but the electrical insulation of the two cores, and their distance apart, must be thoroughly well assured. This rule is equally applicable to conductors of the same polarity.

11. *Flexible Wires.*—Flexible wires are only to be used when they are inevitable. They are to be joined up to the apparatus in such a manner that the insulation of the wires cannot be torn off. They are to be connected up to thick wires by means of carefully-soldered joints. A fuse wire is to be placed at one of the points of connection between a flexible wire and the two main conductors.

12. *Soldered Joints.*—Soldered joints are to be done without the use of corrosive liquid substances. They should not form weak points, either mechanically or electrically, and the electrical insulation must be restored with insulating materials equivalent to those which form the covering of the cables or wires.

13. *Switchboards and Auxiliary Apparatus.*—It is always desirable that circuits should branch off from switchboards, subdivided as far as possible. These switchboards are to be kept well away from the walls, and the wires and cables are as far as possible to be joined up on the front. Necessary precautions must be taken to avoid short circuits due to contact with some metallic object.

14. *Cut-Outs.*—Each circuit is to be provided at its starting point with a double-pole cut-out. Each branch circuit is to be similarly fitted, and also each sub-branch carrying 5 amperes. The cut-outs must be easy of access and shielded from inflammable materials.

15. *Apparatus.*—If any piece of apparatus carries a large number of lamps, the lamps are to be divided into several groups, none of which must consume more than 5 amperes, and each group is to be provided with a double-pole cut-out. Lustres, brackets, &c., used exclusively for electricity, are to be electrically insulated at their point of support, and the body of the apparatus is not to form part of the circuit. Their sockets are to be fixed so as not to turn. When these apparatus are used both for gas and electricity they must fulfil the following conditions:—

(i.) The frame of the apparatus must be electrically insulated from the gas mains by at least 500,000 ohms.

(ii.) Incandescent lamp sockets and the framework of arc lamps must be electrically insulated from the frame of the apparatus.

(iii.) Finally the wires, well insulated and protected, are to be fixed so as to follow the shape of the apparatus, and so as not to be injured by the heat of the gas.

16. *Arc Lamps.*—Each arc light circuit is to include a switch and a fuse wire. If resistances are used they must be fixed in such a manner as to avoid contact with any inflammable material, and sufficiently removed from the wall to prevent it being injured by the heating of the wire. They must also be arranged so that circulation of the air is assured.

17. *Insulation.*—The insulation must be such that in any section of the installation the current leakage between a conductor and earth or between the two conductors shall not exceed one ten-thousandth of the current which is supplied to the apparatus connected to that section. For instance, a branch circuit traversed by 10 amperes should have an insulation such that the leakage current does not exceed 0·001 ampere, and in this particular case with 100 volts on the circuit its insulation will be at least 100,000 ohms.

* By this is meant a conductivity corresponding to a specific resistance less than 1·8 microhm-centimetre.

† [To convert amperes per square millimetre into amperes per square inch multiply by 645. Wire of ·9mm. diameter is approximately No. 20 B.W.G.—ED. *E.*]

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The Electrician.

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THE RETURN TO ELECTROSTATICS.

Time's latest revenge is taking us back a century to experimental appliances of an order fondly believed by some to be as extinct as the dodo. The demand for cheap supplies of electric energy for lighting and power has led to the commercial development of systems of electrical transmission over long distances from generating stations at places where power was cheap, to centres of distribution where power would be dear, or where engines and running machinery would be inadmissible. The commercial conditions of long-distance transmission have in their turn caused a development of high potential systems, without which the cost of conductors for transmission of the current would have been prohibitive. And with the advent of high-potential systems there have come within the consideration of the electrical engineer a host of phenomena which are almost wholly absent from low-potential work. Engineers in charge of low-pressure electric generators and lamps working at only a hundred volts or so, are not much troubled with questions of static charges, or with surface leakage, or with the piercing of insulating materials by sparks. The phenomena of the Leyden jar, the charge and discharge of insulated conductors, familiar as they were to the electricians of the last century, who worked with frictional machines, and the time honoured paraphernalia of pith balls, gold-leaf electroscopes, glass-legged stools, and universal dischargers, were of no concern to the low-pressure engineer, whose stand by was Ohm's law, and whose ideal of a good insulation was expressible in megohms measured on a Wheatstone's bridge by the aid of a couple of Leclanché cells. But all this is changed with the advent of high-pressures. The surface charges that might be insignificant at a pressure of 100 volts become serious at pressures of 10,000 or even 2,000. Insulation must not

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simply be regarded from the point of view of non-conduction measurable in megohms; it must be considered from the point of view of its mechanical power to resist being pierced by spark discharges. In short, electrostatics, the oldest branch of the science, which ever since the invention of the voltaic pile in the year 1800, has been dropping into second-rate importance as compared with the electrodynamic and electromagnetic branches of the science, has once more become of some significance for the industrial side of the science of electricity.

About thirty years ago there was indeed a partial revival of interest in electrostatics when a study of atmospheric electricity led Sir WILLIAM THOMSON to devise that remarkable series of electrometers, the "divided ring," the "quadrant," the "absolute," and the "portable," which still are used as instruments of research. The same great physicist has quite recently continued this series by the evolution of three new forms: the "electrostatic voltmeter," the "multicellular," and the "new gold-leaf" instruments. These are all "repulsion" instruments, mere modifications of the same fundamental principles as are to be found in the old pith-ball electroscope of JOHN CANTON, and the gold-leaf electroscope of ABRAHAM BENNET, to say nothing of the more accurate electrometer of PELTIER. Their significance lies not in their inherent principles of construction, but in the practical needs of the electric engineer which has called them forth.

Simultaneously with the evolution of the modern electrometer there has gone forward an evolution of the electrostatic generator, which if of less practical importance is of no less interest from the scientific point of view. We refer of course to the evolution of the influence machine which has superseded the old frictional machines that were previously used. "How to make a cylinder electrical machine" may be a sufficiently enthralling pastime for the amateur schoolboy to cause him to purchase a journal devoted to this sort of useless "science," but it would have been much more sensible to give him instructions how to make an influence machine of rational type. Nevertheless, the influence machine, though to-day but an instrument of research, is destined to receive more important industrial applications than to serve—as thousands of little portable influence machines to-day are serving—as a domestic gas-lighting apparatus. For thirty years also the evolution of the modern influence machine has been in progress. At that date Sir WILLIAM THOMSON and CROMWELL VARLEY were devising forms of self-exciting machines with a view to their employment in telegraphic signalling. A few years later came the further designs of TOEPLER and of HOLTZ, the latter of whom has introduced endless modifications in detail. Then came a lull, until in 1881 Mr. JAMES WIMSHURST produced the first of his now widely-known machines—the only forms of influence machine really adapted for use in an uncertain climate such as that of the British Islands.

The introduction of another branch of science into the already desperately scientific work of the electrical engineer will tend, no doubt, to create a third class. We already have continuous-current men, who set their faces against alternating intricacies; they are quite right not to bother about them if they are busy enough with what Mr. MASSEY calls the straightforward variety. We have alternating men, who, like our American cousins, want to see the wheels go round; but who leave the theory to professors and third-year students. And now, perhaps, we shall have high-pressure men, who, if not making daily use of pith balls and rubbed sealing wax, will be competent to deal with and to apply for practical purposes those thousands of volts which are the strange outcome of modern electrical engineering.

THE ELECTRICITY SUPPLY BUSINESS IN LONDON.

In devoting its energies to the thankless task imposed upon it by Parliament, the Board of Trade has naturally incurred no small amount of odium amongst electric light company promoters. However, there are compensations in all things; and it has at any rate made it possible for the unsophisticated to obtain a tolerably correct notion of the present position of the electrical supply business. In another column will be found two Tables, compiled respectively from the Capital and Revenue accounts of the eight leading metropolitan electric lighting companies, as set forth in the returns made by them to the Board of Trade for the year 1891. It has been our object in preparing these figures to enable the reader to see at a glance the main financial characteristics of each concern, and to base the Tables wholly and entirely upon the companies' accounts, as presented to the Board of Trade. With regard to the three remaining statutory electricity supply companies of the Metropolis, two, the City of London Electric Lighting Company and the New Cadogan and Belgrave Electric Supply Company, have not, at the time of writing, got properly to work; while the Electricity Supply Corporation declines to furnish us with a copy of their returns. In calculating the number of Board of Trade units sold by each Company we have merely divided the total receipts under the head of current sales by the selling price of the Board of Trade unit. Except in one case—that of the Kensington and Knightsbridge Electric Lighting Company—it has been impossible to make allowance for the rebates usually given to large customers; the total cost of production of the unit as worked out by us is, therefore, in all probability slightly too high in every case but one. We should be very glad to receive any further information as to actual output, in view of the republication of our Tables on another occasion.

Turning to the Table of Capital Expenditure we find that up to December 31, 1891, the eight companies referred to had actually spent over £2,000,000 on lands, buildings, plants, mains, &c., of which nearly £600,000, or 30 per cent., had been devoted to machinery alone. The manner in which each individual company concerned has allocated its expenditure does not exhibit so many startling differences as might have been expected. Thus the Metropolitan Company has devoted over one quarter of its money to buildings, while the average figure of its competitors may be taken at about one-sixth. On the other hand, the St. James' Company, owing to the fact that it has been obliged to locate its generating centres in the very heart of the best districts of the West-End, has expended over 21 per cent. of its capital on lands, against 0·09 per cent. for the House-to-House and 2·5 per cent. for the Metropolitan Company. Nearly half a million of money is now to be found beneath the streets of London in the shape of copper and insulation, while on meters some £27,000 has been expended.

Coming now to the Revenue Accounts, it is a matter for some thankfulness, considering the novelty of the enterprise, the severe competition, and the Parliamentary disabilities under which the electricity supply industry labours, that only two companies should have spent more than they have received. If we exclude these two unripe concerns on the one hand and the over prosperous St. James' Company on the other, the average ratio of expenditure to receipts comes out at about 75 per cent., a by no means remarkably high figure for electrical "infants." The St. James' Company, happily for its shareholders, spends but little more than sixpence for every shilling that it earns. The ratio of generating expenses to total expenditure shows some noteworthy

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Analysis of the Revenue Accounts for 1891 of the

Companies.	Board of Trade units supplied during 1891.	Price of Board of Trade unit during 1891.	Receipts during 1891.	Expenditure during 1891.	Ratio Expenditure / Receipts	Total expenditure per Board of Trade unit sold.	Generating expenses.	Per cent. of the year's expenses.	Generating expenses per Board of Trade unit sold.	Distribution expenses.	Per cent. of the year's expenses.	Distribution expenses per Board of Trade unit sold.	Management expenses.
		d.	£	£	%	d.	£	%	d.	£	%	d.	£
1. Chelsea Electricity Supply Company *c*	290,458	8	10,172	8,422	82·8	6·96	5,260	62·4	4·34	810	9·6	0·67	1,802
2. House-to-House Electric Light Supply Company *c*	230,242	8	8,328	6,078	72·9	6·33	4,827	79·4	5·03	123	2·0	0·12	593
3. Kensington and Knightsbridge Electric Lighting Co.	385,050	8	13,188	8,806	66·7	5·49	5,334	60·5	3·32	1,087	12·33	0·68	939
4. London Electric Supply Corporation *c*	457,300	7¼	15,561	22,518	144·7	11·81	10,044	44·5	5·27	3,267	14·5	1·71	5,272
5. Metropolitan Electric Supply Company *c d*	1,250,233	7¼	43,747	34,627	77·7	6·53	26,694	78·3	5·13	163	0·5	0·03	4,015*b*
6. Notting Hill Electric Lighting Company *c*	30,000	8	1,623	2,178	134·2	17·4	705*b*	32·3	5·60	190	8·7	1·52	730*b*
7. St. James's and Pall Mall Electric Light Company *c*	1,067,990	7	31,898	16,323*a*	51·1	3·66	10,587	64·9	2·38	600	3·7	0·13	3,624
8. Westminster Electric Supply Corporation *c*	573,385	8	19,455	13,913	71·5	5·81	8,713*e*	62·2	3·64	—	—	—	3,246

a This figure does *not* include the sum of £4,013 set aside for depreciation, nor the sum of £1,000 placed to "redemption fund" account.

b Proportion only.

c The selling price of the Board of Trade unit is taken from the table on pp. 144-145 of "*The Electrician*" *Electrical Trades' Directory and Handbook* for 1892. From the figures given in this Company's return it is impossible to make allowance for the usual rebates to large customers, &c, the *cost* of the unit as given is therefore, probably, slightly too high.

d During 1891 this Company sold £22,683 worth of current per meter at 7¼d. per Board of Trade unit; and £15,084 worth under contract. As the nearest approach to probability, the Board of Trade units sold under contract have been taken at 7¼d. also. That this is not far wrong can be

variations. In the case of the House-to-House Company, for instance, this ratio is nearly 80 per cent., against 32·3 per cent. for the Notting Hill Company, the average figure being approximately 60 per cent. The low-pressure and alternating companies seem much on a par in this respect. The total number of units sold during 1891 was a little over 4¼ millions, which, taking the 8-c.p. lamp at 32 watts and equivalent to a 5ft. gas burner, corresponds to 132,800,000 lamp hours, or 664,000,000 cubic feet of gas. The output of the Gas Light and Coke Company for the half-year ending December 31, 1891, was 10,000,000,000 cubic feet; so the whole of the electric lighting by supply companies corresponds at present to only 6·64 per cent. of the output of this one gas company.

Having given some rough averages, we will look more closely into some of those figures amongst which it is possible to strike an average. The amount of capital spent in land cannot be so treated on account of the wide differences, but the following averages fairly represent the proportion spent on buildings, plant, and mains:—

Average Proportion of Expenditure of Capital of the Eight Companies.

Buildings	15·5	per cent.
Plant	31·2	,,
Mains	30·6	,,
Miscellaneous	22·7	,,
	100	

When we come to the revenue accounts we find very wide differences, to be accounted for partly by different systems of allocating expenses to generation and to distribution. This difficulty is, indeed, shirked by the Westminster Electric Supply Company, which lumps these together. An example of this is found in the £163 for distribution set down by the Metropolitan Company, who supplied one and a quarter

Capital Expenditure up to December 31st, 1891, of the Statutory Electricity Supply Companies at present at work in London.

COMPANIES.	Authorised Capital. (Share and Loan).	Paid-up Capital.	Expended Capital.	Details of capital expenditure.	Lands.	Capital Expended.	Buildings.	Capital Expended.	Plant (incl. Transformers and Accumulators).	Capital Expended.	Mains.	Capital Expended.	Meters.	Miscellaneous.
	£	£	£		£	%	£	%	£	%	£	%	£	£
1. Chelsea Electricity Supply Co.	160,500	72,385	74,720		548[1]	0·7	10,254	13·7	34,297	45·9	17,977	24·0	2,875	8,768[2]
2. House-to-House Electric Light Supply Company	130,000	58,820	58,376		56	0·09	7,862	13·4	22,270	38·1	16,151	27·6	2,272	9,763[3]
3. Kensington and Knightsbridge Electric Lighting Company	425,000	132,930	140,604		5,713	4·07	16,039	11·35	46,147	32·65	51,215	36·3	4,413	17,077[4]
4. London Electric Supply Corporation	1,500,000	797,520	753,428[5]		124,352			16·5	198,625	26·3	148,096	19·6	5,827	27,643
5. Metropol. Electric Supply Co.	500,000	497,486	486,926		12,388	2·5	125,010	25·6	191,866	39·4	106,193	21·8	5,399	46,067[6]
6. Notting Hill Electric Lighting Company	150,000	70,020	67,845		7,390	1·09	10,797	15·9	12,858	18·95	26,794	39·5	572	9,433
7. St. James' and Pall Mall Electric Light Company	300,000	155,000	139,458		29,895	21·4	13,144	9·4	41,581	29·8	38,163	31·5	2,850	13,822
8. Westminster Electric Supply Corporation	400,000	329,400	297,640		16,916	5·7	54,091	18·1	70,730	23·7	133,714	44·9	7,649	14,537[7]

[1] Includes property subject to £800 mortgage.
[2] Includes £8,151 for provisional order, preliminary and development expenses.
[3] Includes £7,500 for patent rights and covenants with managing director.
[4] This includes £15,000 purchase of Kensington Court Company, Limited.
[5] This includes purchase of Sir Coutts Lindsay and Co., £248,876, equivalent to 33 per cent. of the total capital expenditure.
[6] This includes £33,894, "proportion of management and general expenditure chargeable to capital."
[7] This includes £10,133, purchase money of City of Westminster Electrical Syndicate.

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Statutory Electricity Supply Companies at Work in the Metropolis.

Per cent. of the year's expenses.	Management expenses per Board of Trade unit sold.	Rent, rates, taxes, &c.	Per cent. of the year's expenses.	Rent, rates, taxes, &c., per Board of Trade unit sold.	—	Coal.	Per cent. of generating expenses.	Cost of coal per Board of Trade unit sold.	Oil and waste, &c.	Per cent. of generating expenses.	Cost of oil, &c., per Board of Trade unit sold.	Salaries and wages.	Per cent. of generating expenses.	Salaries and wages per Board of Trade unit sold.	Repairs and maintenance.	Per cent. of generating expenses.	Cost of repair and maintenance per Board of Trade unit sold.
%	d.	£	%	d.	Details of generating expenses.	£	%	d.	£	%	d.	£	%	d.	£	%	d.
21·4	1·48	452	5·3	0·37		2,692	51·1	2·22	866	16·4	0·71	1,079	20·5	0·89	621	11·8	0·51
9·7	0·61	394	6·5	0·41		2,595*f*	53·8	2·70	—	—	—	1,711	35·4	1·78	427*g*	8·8	0·42
10·66	5·86	758	8·6	0·47		2,057	38·5	1·28	466	8·75	0·291	1,422	26·7	0·886	1,331	25·0	0·83
23·4	2·76	2,833	12·5	0·47		4,419	44·2	2·39	1,161	11·6	0·61	2,960	29·6	1·55	1,502	15·0	0·78
11·8	0·77	3,153*b*	9·2	0·60		13,732	51·4	2·63	2,558	9·6	0·49	7,164	26·8	1·37	3,238	12·2	0·62
33·4	5·84	121	5·5	0·96		160	22·7	1·28	54	7·6	0·43	151	21·4	1·20	225*h*	31·6	1·80
22·2	0·81	1,511	9·2	0·34		4,668	44·0	1·05	771	7·3	0·17	3,444	32·6	0·77	1,702	16·1	0·38
23·2	1·35	1,567	11·2	0·66		3,581	41·1	1·49	985	11·3	0·41	3,799	43·7	1·59	347	4·0	0·14

seen by the agreement between the ratio of $\frac{\text{Expenditure}}{\text{Receipts}} = 78$, and $\frac{6{\cdot}53}{7{\cdot}25}$d. = ·88; the difference means that some 10 per cent. more units were sold than we have figured out by taking the average contract price at 7¼d.; it also means that the figure 6·53d. is about that amount too high.

e The generation and distribution expenses are lumped together by this Company, whose accounts are not made up according to the Board of Trade form.

f Oil and waste included, and less £458 for experimental runs.

g To which might be added £400 transferred to "suspense renewals account" on account of exceptional renewals.

h Including an item of £114. 15s. 6d., "cost of temporary boilers."

million units, compared with the £190 of the Notting Hill Company, who supplied less than one-third of a million.

Generating expenses per Board of Trade unit....	*4·34	†3·975
Distributing	*0·7	†0·326
Management	*2·43	†1·815
Rates and taxes	*0·655	†0·53

* Average of eight companies.

† Excluding London Electric Supply Company and Notting Hill Company, both of these companies running considerably below full load.

The following average costs of coal must be taken in connection with the difficulty, to which we have already alluded, of ascertaining the actual number of Board of Trade units sold. Explanations will, no doubt, be forthcoming to account for the fact that the alternating companies spend rather more than twice as much as the continuous-current companies on coal per unit.

Details of Generating Expenses.

Average cost of coal per Board of Trade unit	1·88d.
,, ,, continuous-current supply systems ..	1·46d.
,, ,, ditto, excluding Chelsea.....	1·275d.
,, ,, alternating-supply systems	2·57d.

Supply Companies in order of Consumption of Coal per Board of Trade Unit.

	d.
House-to-House (including oil, &c.)	2·70
Metropolitan	2·63
London	2·39
Chelsea	2·22
Westminster	1·49
Kensington and Knightsbridge.....	1·28
Notting Hill	
St. James' and Pall Mall.....	1·05

PRICING GOODS AT THE COLUMBIAN EXPOSITION.

Last week we gave some extracts from *Engineering* upon the trick which has been tried at Chicago. It appears that the matter has turned out to be of such importance, that is to say, the participation of foreign exhibitors was recognised as being too valuable to be sacrificed, that the authorities have quickly climbed down, and the guarantees which had been cancelled are now confirmed. Our contemporary waxes indignant about this "unworthy intrigue," and says that "the unscrupulous perpetrators of the circular" have been "striking a surreptitious blow at foreign trade competitors." But the Chicago executive, which it loudly exonerates from any participation in, and even knowledge of, the stratagem, is said to be now "fully alive to the dangers to which the Exposition may be exposed from such intrigues, and they will promptly dissipate any future plots."

Some of our readers will think that this language is rather too strong. But why should the authorities be deprived of the "credit" of an example of national "smartness"?

In our article of last week we advised intending exhibitors to the Chicago Exposition not to arrive at any conclusion upon the complications that had almost suddenly arisen between foreign exhibitors and the executive of the Columbian Exposition, due to the discovery that a circular had been issued from the State Department at Washington withdrawing a privilege which had been already fully conceded to foreign exhibitors; the only important privilege that would induce industrials from abroad to be present at Chicago; and we added that the development of events could not long be delayed. We did not believe, when giving that counsel, that the solution to the difficulty was so close at hand; nor—we will frankly admit—were we prepared for so satisfactory and complete a solution in so short a time.

We have, therefore, the greater satisfaction in being able to announce on the highest official authority from Chicago, that what may be called the Wharton-Davis circular incident is at an end; that the original guarantees to foreign exhibitors which that circular annulled, are wholly confirmed; and that exhibitors may now remain quite satisfied that no further attempts will be made on the liberty of action conceded to them from the beginning on this all-important point. We have received from Chicago telegrams from the executive confirming this assurance, and we have also received from Mr. Robert S. McCormick an official communication to the same effect based on instructions sent to him from the Director-General, Colonel George Davis. As to the exact manner in which this unlooked stumbling-block that had been placed in the path of foreign exhibitors has been swept away, we are of course at present without detailed information; but we know enough of the matter to be able to say, that if on the one hand the earlier part of the incident had naturally produced a most unfavourable—we might rather say a disastrously unfavourable—impression, its conclusion throws a brilliant light upon the American method of dealing with an unjust and unworthy enterprise.

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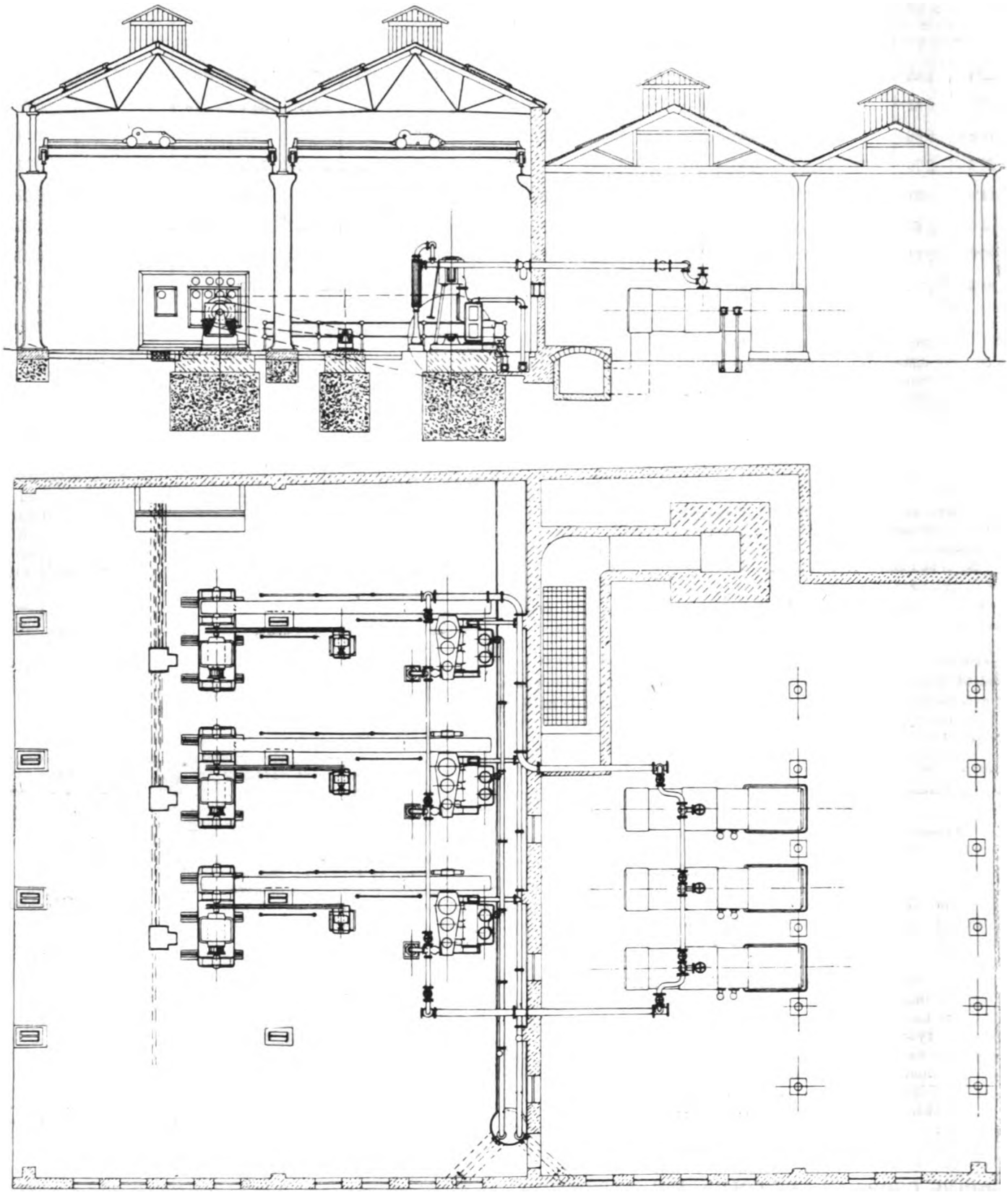
ELECTRIC SUPPLY STATION AT OXFORD.

In our issue of June 24th we gave a description of the system of electric supply used at Oxford, and this week we publish drawings of the switchboard, an illustration of the magnetic switch, and a plan and elevation of the generating station. The switchboard at the central-switch station to which we have already referred in our general description of the system (*The Electrician*, June 24, 1892, p. 195) consists of four parts or sections. The one on the left, with three ammeters, voltmeters, and resistance switches, is the battery board. The next is the termination of the high-pressure mains from the generating station. The part marked H T B is one of the "home transformer boards," and alongside this a Thomson electrostatic voltmeter is shown in outline. The part on the extreme right, consisting of four sections, is the dynamotor or continuous-current



Elevation and Plan of the Oxford Generating Station at Osney. Scale, 16ft. to 1in.

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transformer board for starting and controlling the sub-station transformers. Returning to the battery board, we find surmounting the whole, three battery voltmeters, B V. Below these are the battery ammeters B A, and connected with the two outer ones are two regulating switches R S, and between them are placed two main battery switches B S. The regulating switches are coupled, as shown by the dotted lines, to different cells at one end of each battery, so that the number of cells in circuit may be altered. There are in all 114 cells, these are connected in two sets of 58 in parallel when discharging. When charging, the cells are connected in three sets of 38 in parallel, and are charged off the 100-volt network. This change in the coupling of the cells is effected by means of a throw-over and discharge switch; the switch itself is not shown in the illustration, but the terminals of it are marked C & D. At the bottom of this part of the board three regulating resistance switches R R S are fixed. The next compartment, marked G S C, contains the main ammeter and switches. The two pairs of dotted lines running downwards represent the two high-pressure mains from the generating station; and the other two, marked F E L, are future extension leads. Below these switches the battery fuses B F are fixed.

The home transformer board, of which one-half only is complete, marked H T B, is provided with the high-tension ammeter H T A, and below this is the high-tension automatic double-pole cut-out and switch H T S, very similar to the device described in *The Electrician*, Vol. XXVI., p. 108, in connection with the Manchester-square station of the Metropolitan Electric Supply Company. The starting and regulating resistance switch S R S is connected to the high-tension winding of the dynamotor, as shown diagrammatically at H T A*.

The mode of starting and regulating the dynamotors by means of this switch has been already described in our previous article. Passing now to the low-tension circuit generated in the low-tension armature L T A*, the mains pass upwards to the automatic cut-out A C, and thence, through the low-tension switch L T S, to the low-tension supply network. The current being indicated on the ammeter N A, and the pressure on the voltmeter N V. It is intended, when the demand increases, to provide another dynamotor at the central-switch station; and the necessary switches will be provided on the space shown vacant. The four sets of switches shown on the right, control the distant dynamotors. A dynamotor and magnetic switch are shown diagrammatically, connected with the low-tension network L T N. Pilot voltmeters, P V, at the top of this board show the pressure at various points on the network. When the pressure at any point is found to be falling, and the attendant judges that the assistance of a dynamotor is necessary, he closes the low-tension operating switch L T O, which short-circuits the voltmeter P V, and allows a current to flow through the long-pull magnet of the magnetic switch. We give two outline illustrations and a reproduction of a photograph of this ingenious device. The iron core and armature disc are clearly shown in Figs. 2, 3, and 4, below the iron-clad solenoid. The pilot-voltmeter circuit passes round these solenoids, but the feeble-voltmeter current is of course unable to move the armature. On closing the switch L T O, Fig. 1, the armature is lifted, and raises the links and pawls which hang from it. This action pushes round the ratchet wheel, and the opening of the switch immediately afterwards allows the links and pawls to drop, moving the ratchet wheel again. This causes the double-break switch to open or close alternately as has been already described. A massive coil of three turns carrying the whole low-pressure current, if strongly excited by a heavy load or short circuit, raises the hinged armature and allows a strong spiral spring to pull open the switch.

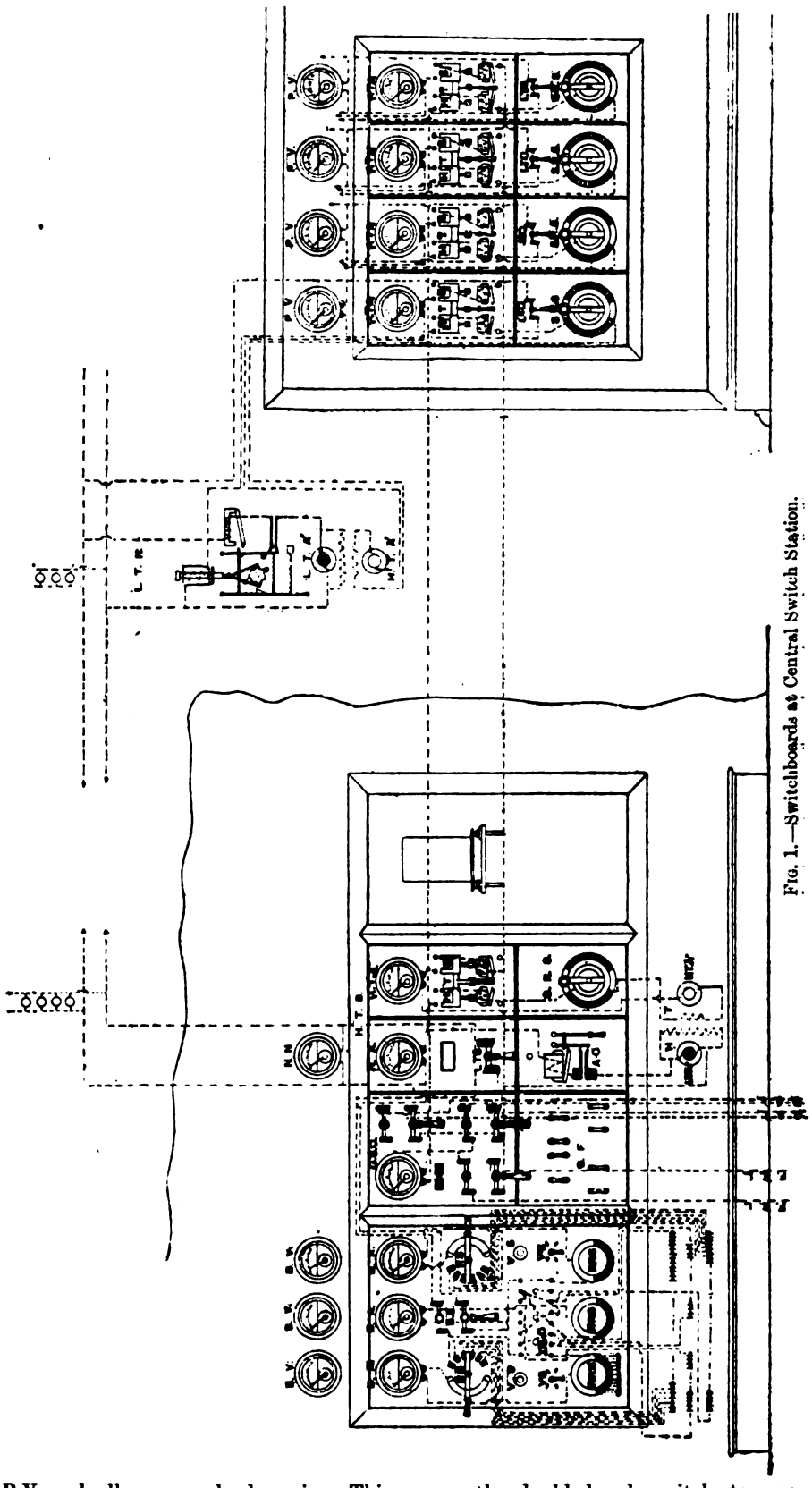

Fig. 1.—Switchboards at Central Switch Station.

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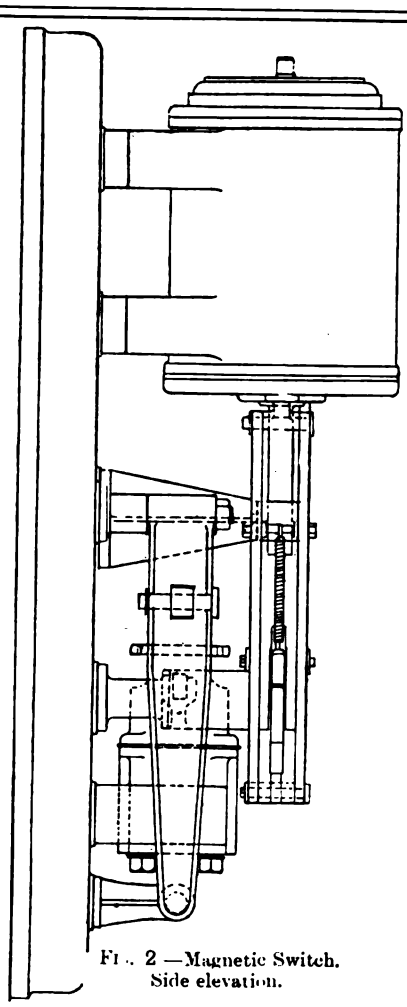

Fig. 2.—Magnetic Switch. Side elevation.

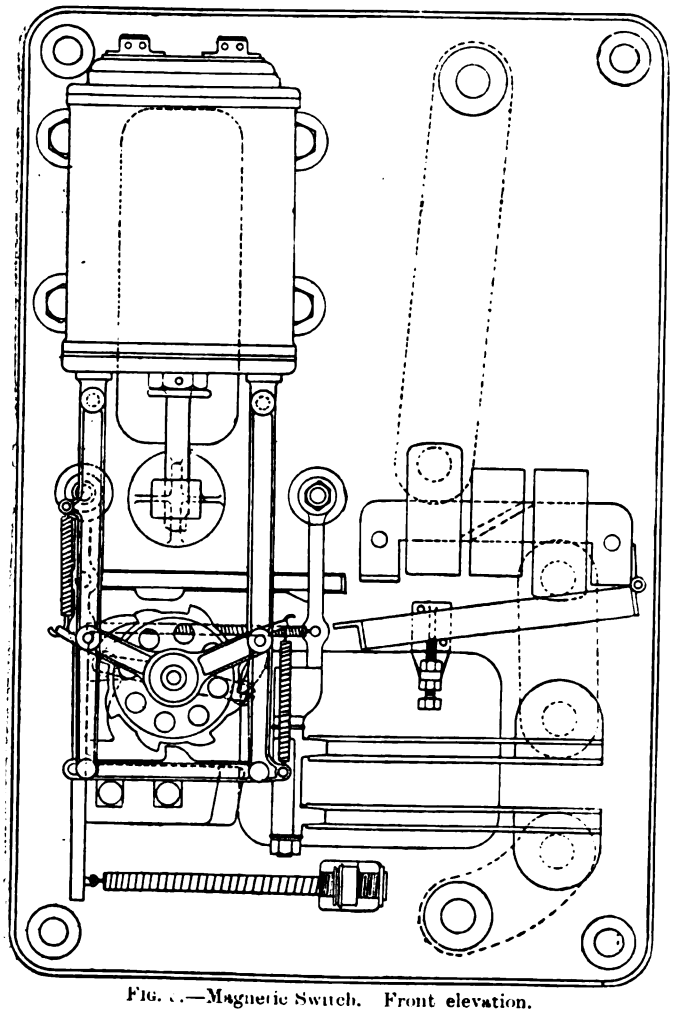

Fig. 3.—Magnetic Switch. Front elevation.

The high-tension circuits are operated and protected by the combined double-pole switch and cut-out H T S. Above these

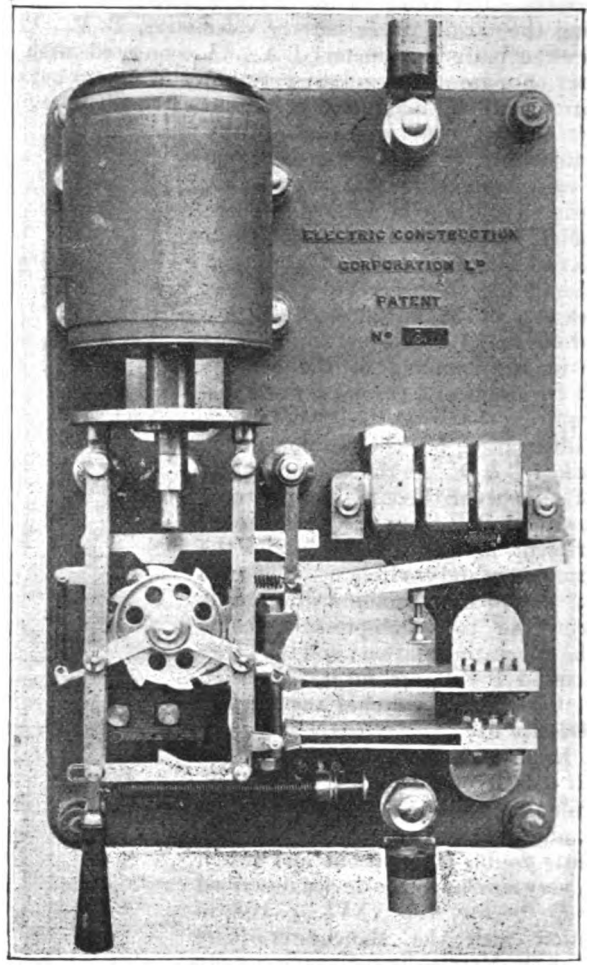

Fig. 4.—Magnetic Switch.

are the high-tension ammeters H T A. No low-tension ammeter is shown, since the dynamotors are left to themselves and require no attention.

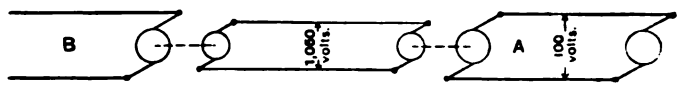

Fig. 5.
Method of Connecting Continuous Current Transform r for Testing.

The dynamotors, or continuous-current transformers, have been tested by coupling two together, as in Fig. 5. The dyna-

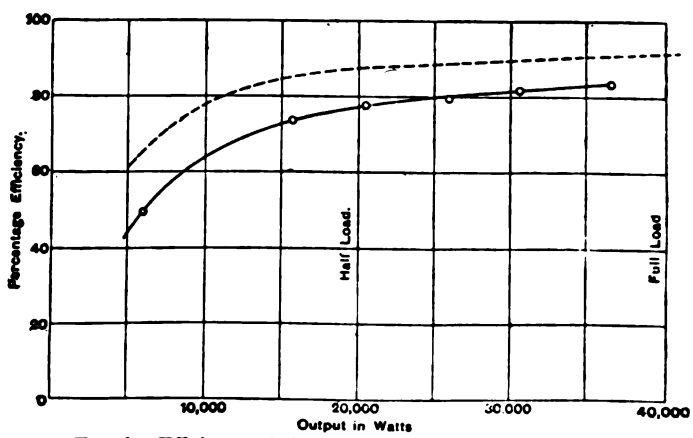

Fig. 6.—Efficiency of Continuous Current Ttransformer.
—— Combined efficiency of two transformers
----- Efficiency of one transformer.

motor A was run from a generator giving 100 volts. The current was transformed by it to 1,050 volts, and this was used to drive a second dynamotor B, transforming down again to

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100 volts. The same instruments were used for both sets of readings, being transferred from circuit A to circuit B, thus practically eliminating any error due to the instruments. The actual readings are shown in Fig. 6, as circles on the full line, this gives the combined efficiency of the two dynamotors. The dotted curve gives the efficiency of a single one for different outputs. We learn that the lighting is giving every satisfaction, and that two colleges are about to begin wiring immediately.

THE VARLEY FUND.

On Friday last week a meeting was held in the Westminster Palace Hotel to consider some means of recognising the services rendered to the electrical industry by the discoveries of Mr. Samuel Varley. Lord Kelvin presided, and was supported by Profs. Silvanus Thompson, J. Perry, D. E. Hughes, Major Flood Page, Messrs. R. E. B. Crompton, Alex. Siemens, &c. Lord KELVIN, after a few preliminary remarks, called upon Mr. Crompton to open the proceedings.

Mr. CROMPTON briefly alluded to the circular which had been sent out calling the meeting, and said he had received a number of replies from Sir Frederick Bramwell, Sir Henry Mance, Prof. Kennedy, Dr. Oliver Lodge, Mr. Preece, and others, all of them speaking very highly of Mr. Varley's work, and wishing to be added to the Committee.

Mr. GATEHOUSE then read a Paper giving a brief sketch of Mr. Varley's life and work, and concluded by pointing out that Mr. Varley's labours had been animated by the true spirit of science, and that in his inventions he had sought the good of the greatest number rather than to reap pecuniary advantage for himself.

Mr. CROMPTON was ashamed to say that until the compound-winding trial, he had known but very little of Mr. Varley's labours. He had been working at the same subject for a long time, but without knowing how thoroughly Varley had already covered the ground, and how completely he had grasped the principles of the subject. As some of them knew, Mr. Varley had not worked for his own advantage, and had not succeeded so well in business as they could wish; and he thought, therefore, that engineers, who had derived so much benefit from his works, ought to take this opportunity of recognising in some substantial way the debt they owed to Mr. Varley. He thought that they might, perhaps, in conjunction with the Institution of Electrical Engineers, approach the Government and obtain a pension from them, which might be supplemented, if necessary, by subscription.

A short discussion then ensued as to the details of the statement to be circulated, in which Profs. Perry, Silvanus Thompson, and Mr. Siemens took part. Mr. Siemens called attention to a letter, which appeared in the *Engineer*, pointing out that Sir Charles Wheatstone first invented compound winding, Mr. Varley first patented it, and Werner Siemens was the first to publish it. It was agreed that the meeting could not commit itself to Mr. Gatehouse's Paper as it stood.

Lord KELVIN suggested that the statement might be supplemented by the addition of the above facts, and pointed out that the law courts only dealt with facts as to the actual patent, irrespective of the date of invention. There seemed no doubt that all three discovered compound winding independently, and almost simultaneously. Among other matters it was suggested that a statement setting forth what Mr. Varley has done should be prepared by Messrs. Siemens, Gatehouse, Silvanus Thompson and Crompton, and this statement should be circulated as widely as possible among members of the electrical profession at home and abroad.

The following resolution was put and carried:—"That this meeting approves of a testimonial being got up on behalf of Mr. S. Varley, and that the whole of these gentlemen who have given their names as willing to serve on the Committee be and are hereby appointed a Committee to act in the question of the Varley testimonial; and that an Executive Committee be hereby appointed, consisting of Lord Kelvin, Prof. S. Thompson, Prof. Perry, Mr. A. Siemens, and the gentlemen who attended the preliminary meeting."

London Chamber of Commerce.—A meeting of the Electrical Trades Section will be held at the offices to-day (Friday), at 3·30 p.m., when the following agenda will be considered:—(1) Minutes. (2) Report of Special Committee appointed to consider the County Council Bye-laws on Overhead Wires. (3) Report as to the action taken by the Special Electrical Traction Committee. (4) Report of the Special Chicago Exhibition Committee. (5) Standardising of machinery. (6) Uniformity of prices. (7) Foreign competition.

CRYSTAL PALACE ELECTRICAL EXHIBITION, 1892.

LIST OF JURORS.

Prof. W. Grylls Adams, D.Sc., F.R.S.
Mr. L. Atkinson, A.M.Inst.C.E.
Prof. W. E. Ayrton, F.R.S.
Mr. Shelford Bidwell, M.A., F.R.S.
Mr. Conrad W. Cooke, M.Inst.E.E.
Prof. W. Crookes, F.R.S.
Mr. W. B. Esson, M.Inst.E.E.
Prof. Geo. Forbes, M.A., F.R.S.
Major-General Festing, R.E., F.R.S.
Capt. Sir Douglas Galton, F.R.S.
Dr. J. H. Gladstone, F.R.S.
Mr. J. H. Greathead, M.Inst.C.E.
Mr. Charles Hall, M.Inst.E.E.
Prof. D. E. Hughes, F.R.S.
Sir Henry C. Mance, C.I.E.
Mr. W. H. Massey, M.Inst.C.E.
Prof. J. Perry, F.R.S.
Mr. W. H. Preece, F.R.S.
Mr. A. Reckenzaun, M.Inst.E.E.
Prof. Henry Robinson, M.Inst.C.E.
Capt. Sankey, R.E., M.Inst.E.E.
Mr. C. E. Spagnoletti, M.Inst.C.E.
Mr. Albion T. Snell, M.Inst.E.E.
Mr. W. E. Sumpner, D.Sc.
Mr. Jas. Swinburne, M.Inst.E.E.
Prof. Silvanus Thompson, F.R.S.
Mr. J. Tomlinson, M.Inst.C.E
Prof. W. C. Unwin, B.Sc., M.Inst.C.E.
Major-General Webber, C.B., R.E.
Mr. J. W. Wilson, M.Inst.C.E.

The following are the awards made by the jurors:

Diploma of Honour.

H.M. Post Office.
L. B. and S. C. Railway Company.
L. C. and D. Railway Company.
L. and N.-W. Railway Company.
National Telephone Company.
Exchange Telegraph Company.
Crossley Bros.
Swinburne, J., and Co.
Willans and Robinson.

Diploma of Honour and Gold Medal.
(Highest Award.)

Brush Electrical Engineering Co.
Crompton and Co.
Johnson and Phillips.
Edison and Swan United Electric Light Company.
Siemens Bros. and Co.

Gold Medal.

Coxeter and Son.
Davey, Paxman, and Co.
Easton and Anderson.
Electric Construction Corporation.
Electrical Power Storage Company.
Glover, W. T., and Co.
Henley's, W. T., Telegraph Works Company.
Laing, Wharton, and Down Construction Syndicate.
Nalder Bros. and Co.
Saxby and Farmer.
White, J.

Silver Medal.

Acme Electric Company.
Anderson, R., and Co.
Andrew, J. E. H., and Co.
Andrews, J. D. F., and Co.
Armstrong's Glass Co.
Barclay and Son.
Benham and Froud.
Bristöl, L.
Britannia Rubber and Kamptulicon Company.
British Gas Engine Company.
British Stone and Marble Company.
Browett, Lindley and Co.
Campbell Gas Engine Co.
Chubb and Son.
Consolidated Telephone Company.
Davis and Timmins.
Day and Co. (Bath).
Dent and Co.
Dick, Kerr, and Co.
Edison Manufacturing Company.
Epstein Accumulator Company.
Ferranti, S. Z. de.
Fielding and Platt.
Fowler-Waring Cables Company.
General Electric Company.
Giles, F., and Co.
Groves, W.
Groth, L. A.
Gülcher (New) Electric Light and Power Company.
Hammer, W. J.
Joel, H. F., and Co.
Laing, Wharton, and Down.
Lloyd and Lloyd.
London Metallurgical Company.
Mosses and Mitchell.
Osler and Co.
Rashleigh Phipps and Dawson.
Richard Frères.
Richards, F. M.
Scott, Ronald A.
Shirley and Co.
Trent Gas Engine Company.
Warby, J. L.
Waygood and Co.
Wells Bros.
Western Electric Company.
Weymersch Battery Syndicate.
Woodhouse and Rawson United.

Bronze Medal.

Allsop and Co.
Anders, Elliot, and Chetham-Strode.
Appleton, Burbey, and Williamson.
Archer Pipe Company.
Becker and Co.
Bishop, W. J.
Bowron, G.
Burnby and Son.
Capitaine Gas Engine Company.
Charlesworth, Hall and Co.
Cooper, H. and J.
Croggon and Co.
Dorman and Smith.
Electric Stores.
Faraday and Son.
Fowler, Lancaster and Co.
Habgood, W. J.
Hartnell, Wilson.
Hindley, E. S.
Hookham, Townley and Co.
Homacoustic Speaking Tube Company.
International Electric Company.
Jenner, T.
Jennings, G.
Jones, A.
Lacombe and Co.
Lewis, J.
Lundberg, A. P.
Maquay Electric Light Syndicate.
Mayer, H.
Mining and General Electric Lamp Company.
Napier and Son.
Newton, F. M.
Riedel, J.
Roberts, Adlard and Co.
Roper's Electrical Engineering Co.
Smith, Samuel, and Son.
Spencer, Edward, and Co.
Spencer, J.
Stegmann, G.
Taylor and Tucker.
Telegraph Manufacturing Co.
Thorpe, Harry.
Tipping, H. S.
"Trusty" Engine.
Zeitz and Co.

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PHYSICAL SOCIETY.

At the ordinary meeting of this Society, held on June 24th, Prof. A. W. Rücker, F.R.S., in the chair, a Paper was read by Mr. W. B. Croft on

"Breath Figures."

He described a number of interesting experiments by which latent impressions of objects such as coins could be made upon glass plates. When such objects were electrified the figures were developed by breathing upon the glass. Prof. Silvanus Thompson referred to other curious latent impressions of a mechanical description upon glass and porcelain.

A Paper was read by Mr. E. Wythe Smith

"On the Measurement of the Internal Resistance of Cells,"

In order to determine the actions which take place in an accumulator during charge and discharge, it is necessary to know the working E.M.F. at the different stages. This might be observed by breaking the circuit; but immediately on doing this the E.M.F. varies at a very rapid rate, so that if only four or five seconds be occupied in taking the measurement an error of 25 per cent. may be made in the difference between the E.M.F. and the terminal potential difference. If time-readings be taken after breaking the circuit and a curve drawn connecting E.M.F. and time, this curve may be produced back in the way described by Prof. Ayrton and others in a Paper at the Institute of Electrical Engineers. But as this method has its objections, in addition to that of interrupting the circuit, it is very desirable to determine the actual working E.M.F. in some other way.

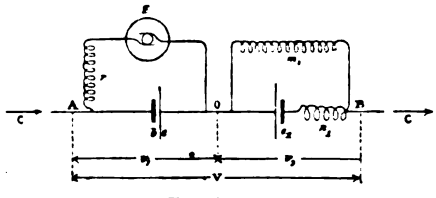

Fig. 1.

The E.M.F. could be readily obtained from the terminal potential difference and the current if the internal resistance were known. It is for the determination of this latter quantity that I have devised the following modification of Mance's method. Of course this method is applicable to the measurement of the resistance of other forms of battery besides accumulators.

In Fig. 1 let the cell of E.M.F. e, and internal resistance, b, be the one experimented upon, r being the resistance of the external circuit which contains an E.M.F., E, for example, that of the dynamo used to charge the cell. This circuit is connected at O with an auxiliary circuit, in which the resistances m_1 and n_1 are so adjusted that the points A and B are at the same potential, the resistance of the cell of E.M.F., e_1, being included in n_1. Suppose a current, C, from some external source to pass through both circuits in series. The potential difference between A and B will now be V. Let potential difference between A and O be v_1, and that between O and B be v_2, $(v_1+v_2)=V$. We have

$$C=\frac{v_1+e}{b}+\frac{v_1+E}{r}=\frac{v_2-e_1}{n_1}+\frac{v_2}{m_1};$$

therefore
$$v_1=\frac{b\,r\,C-r\,e-b\,E}{b+r},$$

and
$$v_2=\frac{m_1\,n_1\,C+m_1\,e_1}{m_1+n_1}$$

$$V=\frac{b+C-r\,e-b\,E}{b+r}+\frac{m_1\,n_1\,C+m_1\,e_1}{m_1+n_1}.$$

But when C=O, V=O,

$$\therefore\ O=\frac{-r\,e-b\,E}{b+r}+\frac{m_1\,e_1}{m_1+n_1};$$

$$\therefore\ V=C\left(\frac{b\,r}{b+r}+\frac{m_1\,n_1}{m_1+n_1}\right).$$

If we measure the apparent distance R_1 between A and B by any convenient method, and if C be the current sent through this circuit between A and B by the testing arrangement, we get R_1 equal to $\frac{V}{C}$;

$$\therefore\ R_1=\frac{b\,r}{b+r}+\frac{m_1\,n_1}{m_1+n_1}.$$

Now if we have three circuits (Fig. 2) connected together at the point O, the cell of E.M.F. equal to e and resistance b being the particular one whose resistance is required, and if the resistances m_1, m_2, n_1, n_2 be so adjusted that the points A, B, and C are at the same potential, the apparent resistances R_1, R_2, R_3 between the points A and B, A and C, and B and C, will have the following values:—

$$R_1=\frac{b\,r}{b+r}+\frac{m_1\,n_1}{m_1+n_1},$$

$$R_2=\frac{b\,r}{b+r}+\frac{m_2\,n_2}{m_2+n_2},$$

$$R_3=\frac{m_1\,n_1}{m_1+n_1}+\frac{m_2\,n_2}{m_2+n_2};$$

$$\therefore\ \frac{b\,r}{b+r}=\frac{R_1+R_2-R_3}{2},\ \text{say, equals } x,$$

then the required resistance of the cell,

$$b=x+\frac{x^2}{r}+\frac{x^3}{r^2}+\&c.$$

If, as in the case of an accumulator, x is small compared with r, then

$$b=x+\frac{x^2}{r}.$$

When an accumulator is discharging, taking $b=x$ gives us a value for b about 2 per cent. too low.

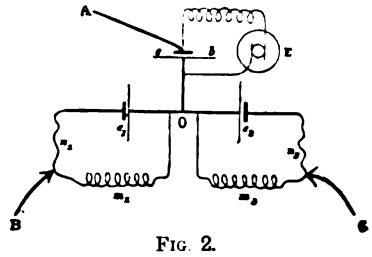

Fig. 2.

If a Wheatstone bridge be employed to measure R_1, R_2, and R_3, there will be no necessity to employ any special instrument in the testing for equality of potential of the points A, B, and C. For all that need be done is to remove an infinity plug on the bridge, close the galvanometer circuit, but not that of the testing battery, and adjust m_1, m_2, n_1, n_2 until the galvanometer remains at zero.

DISCUSSION.

Prof. PERRY inquired how far the results obtained agreed with those got by the older methods, and whether they depended on the time the keys were kept down. In the old methods it was assumed that an instantaneous rise in potential difference occurred on breaking the circuit. This might or might not be true. He was inclined to regard the potential difference and current as functions both of resistance and time. The behaviour of cells seemed to indicate the existence of something like capacity, or rather capacities and resistances in series.

Prof. AYRTON said the Paper was of great interest, for it made possible what could not be done before, viz., to find the resistance of a cell without appreciably altering the current through it. Although the new method required more cells this was not prohibitive, for the result sought was of considerable scientific importance. The same method was applicable for finding the resistance of dynamo armatures when working a quantity which had hitherto been unattainable by direct measurement.

Mr. LANE FOX said the perplexing changes in the potential difference of secondary cells were to be accounted for by changes in the electrolyte which occurred in the pores of the plates. He could detect no flaw in the reasoning given in the Paper.

Dr. SUMPNER remarked that the method was a valuable one, for it depended on bridge tests which could be made with considerable accuracy. On the other hand, it was a false zero method, and therefore liable to errors arising from changes of this zero.

Prof. AYRTON pointed out that these errors could be eliminated by reversing the bridge battery.

Mr. RIMINGTON said, although the testing currents were small, they might affect the E.M.F., and thus introduce an error in b. This might be tested by using alternate currents and a telephone.

In reply to Prof. Perry, Mr. SMITH said the results agreed with those obtained by the older methods to within the limits of accuracy obtainable by the latter methods; this might amount to something like 15 per cent.

A Paper was read

"On the Relation of the Dimensions of Physical Quantities to Directions in Space,"

by Mr. W. Williams.

In February, 1889, Prof. Rücker recalled attention to the fact that in the ordinary dimensional formulæ for electrical quantities the dimensions of μ (permeability) and k (specific inductive capacity) are suppressed. In the discussion on that Paper Prof.

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S. P. Thompson pointed out that lengths should be considered as having direction as well as magnitude; for, if so regarded, difficulties arising from different units, such as *couple* and *work*, having the same dimensions would be avoided. Developing this idea, the author takes three mutually perpendicular lines along which lengths are measured. Calling unit lengths along these lines X, Y and Z respectively, the various dynamical units, such as velocity, acceleration, force, work, &c., are expressed in terms of M, T, X, Y, and Z. The formulæ, then, denote the directional as well as the numerical relations between the units; and the dimensional formulæ are therefore regarded as the symbolical instead of by powers of a single length, and angles and angular displacements by quotients of rectangular vectors, instead of being expressions of the physical nature of the quantities, so far as they depend on length, mass and time. In this system areas and volumes are represented by products of different vector lengths, pure numbers. For physical purposes pure numbers may be defined as ratios of concretes of the same kind similarly directed (if directed at all). A plane angle has dimensions $X^{-1}Y$, X being in the direction of the radius, and Y that of the arc, whilst solid angles have dimensions YZX^{-2}, and radii of curvature Y^2X^{-1}. It is also shown that π is a concrete quantity of the dimensions either of plane or of solid angle. This is of considerable importance in connection with the radial and circuital fluxes in the electro-magnetic field.

In deducing the dimensional formulæ for electrical and magnetic units, the rational and simplified relations given by Mr. Oliver Heaviside in *The Electrician*, of October 16th and 30th, 1891, are used. Instantaneous axes are taken at any point of an isotropic medium (the ether), such that X coincides with the electrical displacement, Y with that of the magnetic displacement, and Z with the intersection of the two equi-potential surfaces at that point. Starting with the relation μH = energy per unit volume, the formulæ for the various quantities in terms of μ are obtained. These simplify down to those of the ordinary electro-magnetic system, by putting $\mu = 1$ and suppressing the distinction between X Y and Z. Similarly, commencing with kE^2 = energy per unit volume, formulæ in terms of k are obtained, which, when simplified as above, give those of the ordinary electrostatic system. Examples of the consistent way in which the results work out are given in the Paper, and the whole subject is discussed in detail both by cartesian and vectorial methods.

The formulæ in terms of μ and k are used to trace out and examine the various analogies between electro-magnetism and dynamics, thereby obtaining a connected dynamical theory of electro-magnetism. Inquiry is then made as to what dimensions of μ and k in terms of M, T, X, Y, Z render the interpretation of electrical and magnetic units simple, natural, and intelligible as a whole. The conditions imposed (for reasons stated in the Paper) are—1st, that the dimensions of μ and k satisfy the relation $[\mu k] = Z^2T^{-2}$; 2nd, that the powers of fundamental units in the dimensional formulæ shall not be higher or lower than those found in the formulæ of the ordinary dynamical quantities; and 3rd, that quantities which are scalar or directed must also be scalar or directed when these dimensions are expressed absolutely. Subject to these conditions, it is shown that the possible dimensional values of μ and k are eight in number. Of these only two lead to intelligible results. These are—I., $\mu = M(XYZ)^{-1}$, and $k = M^{-1}XYZ^{-1}T^2$; and II., $\mu = M^{-1}XYZ^{-1}T^2$, and $k = M(XYZ)^{-1}$. According to I., μ is the density of the medium, electrical energy is potential, and magnetic energy kinetic. By II., k is the density of the medium, electrical energy is kinetic, and magnetic energy potential. Full interpretations of the dimensional formulæ of all the electro-magnetic quantities, as obtained in accordance with the above conditions, are given in the Paper.

DISCUSSION.

Prof. S. P. THOMPSON said the Paper was a very important one, and thought the idea of finding dimensions for μ and k, which would rationalise the ordinary dimensional formulæ, a great step. The use of vectors was a valuable feature, whilst the employment of X, Y, and Z instead of L, removed many difficulties connected with dimensional formulæ. Other difficulties might be cleared up by paying attention to the signs of the vector products and quotients, and to the order in which the symbols were written. Another important matter was the use of Mr. Heaviside's "rational units," a system which merited serious attention. In conclusion, Prof. Thompson expressed a hope that, in accordance with a resolution of the Electrical Congress at Frankfort, both permeability and specific inductive capacity should be designated by Greek symbols.

Prof. O. HENRICI expressed his admiration of the way in which the subject had been treated in the Paper. He had long held that clear ideas of physical quantities were best got by vectorial methods. He also congratulated the author on his treatment of plane and solid angles as concrete quantities.

In a communication addressed to the Secretary, Prof. O. J. LODGE remarked that physicists in England were more or less familiar with the advantages of retaining μ and k in dimensional expressions before Prof. Rücker's Paper of February, 1889, brought the matter closely home to students. The system of mechanical dimensions suggested for electrical quantities in an appendix to "Modern Views of Electricity," was not put forth as the only one possible, but as one having certain probabilities of truth in its favour.

Prof. RÜCKER said that although Mr. Williams and himself had talked over certain minor points in the Paper, the main ideas brought forward were quite original, having been fully developed by Mr. Williams before the author mentioned the subject to him (Prof. Rücker).

A Paper on "Molecular Forces," by Mr. W. SUTHERLAND, communicated by Prof. CAREY FOSTER, was taken as read.

The CHAIRMAN announced that both this Paper and that of Mr. Williams would be printed in the *Philosophical Magazine* during the long vacation, so that they could be fully discussed early next session.

LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

COURT OF APPEAL.—WEDNESDAY, JUNE 29TH.

Mr. R. WALLACE, who was placed at some disadvantage by the loss of his notes of the case, together with memoranda and index of the evidence, in resuming his address to the Court, dealt with Prof. Ayrton's curves of charge and discharge of accumulators, and read extracts from Mr. Drake's evidence. Lord Justice Kay said that he understood that when the battery was charged the volts rose quickly to the point D (see *The Electrician*, Vol. XXVI., p. 102), and that then it bubbled. Mr. Wallace said that was so, and that on beginning to discharge there was a drop of 25 volts. It had been assumed, he said, that the "plateau" of charge was identical with the "plateau" of discharge, but that it was not fair to consider them as being on the same level. They were shown on opposite sides of the page in Ayrton's Paper, and that was how the idea of the "plateau" got into the mind of Mr. Lane Fox's witnesses and of the Attorney-General. The "plateaux" were not at the same level, and therefore it was evident that the "plateau" theory must vanish.

Various curves of experiments were put in, and one of their Lordships asked, "What does B.D. mean?" "Benjamin (!) Drake," was the reply "Then what does P.D. mean?" "P.D. stands for potential difference." After further reading of evidence on charging and discharging of storage batteries Mr. Lane Fox rose and said that he did not dispute that at all; it was all irrelevant, this charging at high volts was not necessary, except for commercial reasons of storage. Lord Justice Kay asked whether it was necessary to charge up as far as B. A long series of extracts from the evidence was then read, and Mr. Lane Fox again rose to say that he did not dispute it. Mr. Wallace said that it was suggested that if they went to a less degree of charge, less current would go in, and they would have to do it for a long time, and it could not be done under a long time. Lord Justice Kay: "Is it necessary to go to B?" Mr. Wallace: "Unless you do you cannot charge at all." Lord Justice Kay: "But fully charge? Lane Fox says you need not got so far." Mr. Wallace: "If you do, you do not get on to the plateau——" Lord Justice Kay: "But we want the evidence." Mr. Wallace: "That is shown——" Lord Justice Kay: "The evidence! the evidence!" Mr. Wallace then read from Prof. Kennedy's evidence.

After a considerable number of extracts from the evidence had been read, Lord Justice Kay said that all that was for the sake of the batteries.

Evidence on an attempt to charge a battery at a pressure never more than 1 per cent. above the normal was then read; and Mr. Wallace said that it would not suffice to supply any practical demand in ampere hours. Lord Justice Kay asked for an explanation of the term ampere-hour, and Mr. Wallace attempted at first to illustrate it by reference to an income of £500 a year, and afterwards by a quantity of water flowing in a stream of so many gallons a minute. After some discussion the Judges failed to understand the explanation, and called on Mr. Lane Fox for assistance. He stated that an ampere hour was a measure of capacity, and represented an ampere flowing for an hour, and that was so much energy. Lord Justice Lopes said that some clear explanation of the term would probably be found in an excellent book by Miss Marie Caillard on Electricity. When at length some idea of an ampere hour had been arrived at, Lord Justice Kay said, "All this is for a great store of current, but Lane Fox does not want it." Mr. Wallace then read extracts from Mr. King's evidence on the point of utility. Extracts from the evidence of Messrs. Miller and Swinburne were then read, and in reply to one of the Judges Mr. Wallace said that the batteries might stop the flicker, but that was not the regulation which Mr. Lane Fox had intended.

Evidence on the use of the switches was then read, and Lord Justice Kay said that they appeared to be an improvement, and it did not show that the system would not work at all without switches. Further evidence was read, but his lordship said that it would only be material if it could be shown that the system would not work without switches. The evidence of Prof. S. P. Thompson was read. Lord Justice Kay remarked that the switches were an improvement for regulation. The evidence of Mr. Crompton was then quoted to show that the system would not work without switches, and a long extract from Mr. Millar's evidence was read.

THURSDAY, JUNE 30TH.

Mr. Lane Fox having omitted to refer to many parts of the evidence during his opening address, Mr. WALLACE read many extracts at Mr. Lane Fox's suggestion; and after the mid-day adjournment Lord Justice Lindley announced that the Court had decided to read the whole of the evidence, but wished to know which portions were considered important. Further extracts from Mr. Drake's evidence were read by Mr. Wallace. A

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discussion between the Judges and Counsel arose on the short duration of the regulation which was admitted by the witness, and on the aims of Lane Fox and of the defendants in their use of secondary batteries. After the reading of the evidence of Prof. S. P. Thompson and Prof. Barrett, Mr. Wallace said that it amounted to this: that the batteries were of no value for regulating. When they were fully charged they were just enough to prevent a flicker. Lord Justice Kay said that he could not understand the evidence of Mr. King. In one place he said that the batteries when charged would prevent flickering for a few moments only; and in another place he said that you may shut up the place, and the batteries would run the lamps all night. Lord Justice Lopes said that he could not understand this contradiction, and Lord Justice Kay repeated that he was unable to reconcile the evidence of this witness on pages 639 and 641 of the shorthand notes.

Passing to the question of switches, further evidence was read, and Lord Justice Kay said that if the invention of Lane Fox was such that it would regulate for a short time, their addition of switches would not affect Lane Fox. The evidence on Prof. Kennedy's tests of batteries was then read; and Mr. Lane Fox, interposing, said that in this case the batteries were not connected to the mains, and it could not be compared with actual work. After copious extracts from evidence, Lord Justice Kay asked why the lamps could not be run from the mains, when both they and the batteries had dropped to 50 volts? Mr. Wallace explained that 100-volt lamps would give no light at 50 volts. Lord Justice Kay referred to other parts of the evidence to show that at 50 volts lamps worked satisfactorily. Lord Justice Lopes thought that that would be an excellent way of working, and that the regulation would then be perfect. Mr. Wallace explained that there was a difference between 100-volt lamps and 50-volt lamps in the thickness and resistance of their filament.

Extracts from Mr. King's evidence were read, in which experiments made for the purpose of the trial were described. A constant current of 80 amperes was used, and the resistance of the circuit being varied, there was a corresponding change in the volts. Diagrams of curves were shown; but after a long explanation Lord Justice Kay said that he did not understand a single word of it. Mr. Lane Fox rose to ask if he had a right to reply on this evidence. Lord Justice Lindley said, "Of course;" and Mr. Lane Fox remarked, "It is all absolute nonsense." After further evidence on the behaviour of batteries, Lord Justice Kay said, "If that is not regulation, I should like to know what regulation is." Mr. Wallace said that that kind of regulation was not what the defendants used batteries for. He denied the utility of it, and said that a battery would only be wasted if it were used for that, and that it would be better to use a dynamo instead. After extracts from Dr. J. Hopkinson's evidence, Lord Justice Lindley said that there was a difference between utility now, and utility in 1878; the Lane Fox system might not be useful now, but it might have been in 1878. Mr. Wallace said that there had been no invention; if Lane Fox had invented a battery it would have been a different thing.

Prof. Perry's evidence about the use of the Lane Fox system at the Grand Hotel, Charing Cross, was read, and Mr. Wallace said that he had had to use switches. Lord Justice Kay said, "No, 'he did use switches,' not 'he had to.'" Evidence about the exhibits at the Crystal Palace and at Paris and Lady Conyers's ball was read; and the switches were described as an obvious development. Mr. Wallace said that Mr. Lane Fox merely took a Planté battery which everybody knew about, and used it to do work which everybody knew it would do, showing no novelty or invention. Anybody might have done it. Lord Justice Kay said, "The man who first applied secondary batteries to dynamos and lamps was a great inventor." Soon after this the Court adjourned.

FRIDAY, JULY 1ST.

Evidence of early examples of incandescent lighting at the Palace of the King of Roumania and elsewhere was read by Mr. WALLACE, and attention was called by him to the fact that switches were used. He read the passage in which Lane Fox claimed to have invented these switches, that Prof. Perry had invented eight years after, and that Mr. Crompton had invented them a few years ago. Mr. Lane Fox rose to say that this was said in joke. The work at the Vienna Opera House and at the Law Courts was referred to, and parts of the cross-examination of Mr. Lane Fox were read. After the first week, the lamps at the Law Courts flared up when the batteries were being charged, but were only red hot when they were run direct from the batteries. Extracts from Mr. Crompton's evidence were read, showing that Faure-Sellon-Volkman cells were used, that the lamps were run from compound dynamos, and that before accumulators were used the light was very good. Lord Justice Kay said, "But they charged the battery to a high point"; Lane Fox says he does not, and that if you do so you must use switches. Mr. Wallace admitted that that was so. Lord Justice Kay continued that if the batteries were charged with 125 volts, switches must be used and the whole question was whether it *was* necessary. Lane Fox, he added, said no. The model (*The Electrician*, Vol. XXVIII., p. 158) was handed up to their lordships, and Mr. Wallace read the description of several of the positions; while Mr. Goddard, solicitor for the defendants, adjusted the wheels, slides and switches. Lord Justice Kay said that it seemed to be a mode of showing that if they had high volts they must have some way of preventing the high-pressure getting to the lamps.

The patent specification, which up to this point in the appeal had received hardly any attention, was read and commented upon by Mr. Wallace. Lord Justice Kay asked whether any word in the title referred to the battery except the word "regulation." Mr. Wallace replied that as the title stood regulation did not refer to the battery, but that "distribution" referred to it. Lord Justice Kay: "But that is left in." Lord Justice Lindley: "The point is that the mode of regulation is altered." Mr. Wallace said that one of the objects of the system was to overcome the resistance of the mains.

Arguing on the insufficiency of the specification, Mr. Wallace said that Lane Fox had not described a workable invention, and the description was ambiguous. He read the following passage from the specification:—The electromotive force of the electric conducting mains should be kept as nearly as possible constant at, say, 100 volts or British Association units of electromotive force. The emphasis, he said, was not on "constant"; that was not important, but on "100 volts." Lord Justice Lindley pointed out that Lane Fox had put it "say, 100 volts." He seemed to have made a good shot. Mr. Wallace said that 100 was a round number. Lord Justice Kay said that "100 volts" could not be the pith of the sentence, because it was preceded by the word "say." It was obvious that the pith was in the word "constant." Mr. Wallace said that while lamps could be made for 50 volts, or lower pressures, Mr. Lane Fox's object was to use high resistance, so as to get over the resistance of the mains. Lord Justice Kay said that that did not impress his mind; and Lord Justice Lindley concurred. Passing to the reference to the batteries, Lord Justice Kay said that the words were "such as Planté," which was very like the other expression, "say." Another passage from the specification was read, and one of the Judges asked what was the object of a reservoir if not to keep the volts constant. Mr. Wallace said it was distinctly claimed *not* that the pressure should be constant, but "to increase the electromotive force." Lord Justice Kay said, "But if the mains drop, *then* it would increase it." Lord Justice Lopes said that the mains would be recouped when the pressure had fallen. Lord Justice Kay observed that they were not talking of current, but of electromotive force. Lord Justice Lindley asked Mr. Wallace how he read the passage; and he replied that Mr. Lane Fox wanted to dot batteries about over a large surface; and when the electromotive force fell, there would be a source of electricity coming out to supply the mains at a lower voltage. It would thus soak in. Mr. Lane Fox wanted a constant current, not a constant electromotive force. He argued that the expression "electric force" throughout the specification meant current, and not electromotive force. Lord Justice Lopes thought this distinction was too fine. Lord Justice Kay said that they could raise the electromotive force by supplying more current; but Mr. Wallace replied that to do that they must have it at a higher electromotive force. In answer to a question, he admitted that this supply would prevent the electromotive force going further down. Lord Justice Lopes: "But that is regulation." Lord Justice Kay: "If it arrests diminution is not that regulation?" Mr. Wallace said that it tended to keep it constant. Lord Justice Lindley: "If you do a thing tending to make a thing more constant, is not that regulating?" Mr. Wallace: "It would be regulating it in one way, but not in another." Lord Justice Kay read regulation to mean keeping 100 volts. Mr. Wallace said that Lane Fox's object was not to supply volts but current. Lord Justice Kay: "But his object was to light the lamps." His lordship added that the current would be of no use if it were not sufficient to light the lamps, and that it must be used intelligently; he would not use electricity which would destroy the lamps. No workman in 1878 would fail to understand that. Mr. Wallace said that it was a question whether he would know it; he might damage the lamps. The point is that the workman would damage the lamps; but there were no lamps, and no experience in lamps. Lord Justice Lindley said that this might require a little practice and skill, but no invention. He put it to Mr. Wallace if a dynamo were running with the lamps lighted, if the belt slipped, there would be a draught upon the mains. Would this be supplied by the batteries even if they were not full? Mr. Wallace said there would be a sudden drop. Lord Justice Kay said that he understood that a battery might be too large because it would never be properly charged.

Mr. Wallace then turned to the disclaimer, and said that Mr. Lane Fox had left in the regulating, but had disclaimed the regulator. Lord Justice Lindley said that the nature of the invention was for keeping the electromotive force constant by the use of batteries and by a regulator. If he struck out the regulator that would not alter the invention. Lord Justice Kay observed that the regulator never entered into the fourth claim, and thought that this was a mere fight about words. Lord Justice Lopes asked why regulation should not apply to both batteries and regulator. Mr. Wallace replied that Lane Fox did not know until 1883 that batteries alone could regulate. Lord Justice Kay said that the regulator was only to regulate the speed of the dynamos, and was devoted solely to that. The batteries were entirely different. If there were a large draught on the mains, that would have nothing to do with the speed of the dynamo. Mr. Wallace replied, that if there were a large demand, that would cause the draught to drop and the electrometer regulator would work. Lord Justice Kay said that the instant there was a drop the battery would act before the regulator had time to act. Mr. Wallace explained that the draught would directly affect the speed of the dynamo.

Mr. Wallace argued that Mr. Lane Fox had not described the same invention in the provisional specification that he had done in the complete. Lord Justice Kay said that the patent was for "improvements," and that these were not all claimed in one claim, but each was claimed by itself. Mr. Wallace said that there was no regulating effect in the battery except by its inherent quality as a reservoir. In the provisional specification there was no mention of batteries for regulating. Lord Justice Kay said Lane Fox intended to have batteries as a reservoir, and found afterwards that they had an advantage which he did not then see, that they would keep the electromotive force constant. Mr. Wallace: "But at the time of the provisional he had not found that out." Lord Justice Lindley said that then if there had been no disclaimer there would have been no disconformity. Mr. Wallace contended that there would have been disconformity anyhow. The batteries were to be used in the first instance only as reservoirs. Lord Justice Kay asked what would be the use of it if not to supply a deficiency. Mr. Wallace replied that it would supply current, but not pressure. Lord Justice Kay said that it was involved in the word "reservoir" that he had this power; but that it was not all expanded in the provisional. He added that the Court was not forced to construe a provisional specification critically, and that they would not do so unless forced. The case of "Woodward *v.* Sampson" was cited by Lord Justice Lindley. This showed that an inventor was not bound to describe every mode in the provisional, but

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if new modes were discovered afterwards he was bound to put them in the complete specification. Lord Justice Kay said that if another advantage were discovered, all that he then knew being given in the provisional, then if an additional one were found, there would be no disconformity. The battery was not changed, its position was not changed; but another advantage was added. Mr. Wallace: "Yes, and is claimed for, and this changes the nature of the invention." Lord Justice Lopes said that there was nothing new in the use of a battery as a reservoir, and that the regulating power had been described in the complete specification. Mr. Wallace said that the public had a right to use a battery as a reservoir. Lord Justice Kay: "But not for electric lighting of incandescent lamps." Lord Justice Lopes asked whether the invention was not in putting the mains and the battery together. Lord Justice Kay compared this invention to a watch with a peculiar escapement, it was claimed that it would go more regularly, but in the complete specification it was said that not only would it go more regularly, but it would last for years without cleaning. Mr. Wallace: "But Mr. Lane Fox did not invent the use of reservoirs." Lord Justice Lopes: "But the invention was the putting together of the batteries and mains and lamps."

"Harrison *v.* Cox-Walker" was cited, and evidence was read on the size of the cells. Mr. Wallace said that Mr. Lane Fox had neglected the "back volts," and thought that the large cells would reduce the internal resistance, and so allow of charging at lower pressure; but the back volt constituted 99 per cent. of the resistance. Mr. Wallace then summed up his arguments on Mr. Justice A. L. Smith's judgment as to infringement, disconformity, and that the invention was not workable.

Mr. Wallace then proceeded to open his cross-appeal against those points which had had been given by Mr. Justice A. L. Smith in favour of Mr. Lane Fox. He argued that the defendants did not infringe because they used switches, and because their batteries were concentrated at the station and not dotted about. The question of "earth" was then discussed at great length. Mr. Wallace said that although the earth was disclaimed, something was left in the specification which was bad. If it were granted that the specification directed that either the earth might be used as the return conductor, or another conductor might be used, the patent would be bad if the earth were unsuitable. "Simpson *v.* Halliday" was cited on this point. In that case a chemical process was described, and it was directed that it might be carried on with heat or without heat. One of these was impossible, and the patent had been held to be bad. Mr. Wallace denied that the term "earth" had any technical meaning in 1878. Lord Justice Kay asked why then, were inverted commas used. Mr. Wallace referred to the judgment of Mr. Justice A. L. Smith, who held the facts for the defendants, but the law against them, that is to say, that it was not an essential part of the invention. Mr. Wallace asked Mr. Lane Fox if he would admit Mr. Justice Smith's facts on the earth, but Mr. Lane Fox declined to do so. Lord Justice Kay said that it appeared to matter as little as if a man wore his hat on the right side of his head or on the left, on which one of the experts on the defendants' side remarked in an audible whisper, that he might have patented the wearing of it on the right-hand side, a comment which his lordship appeared to fully appreciate. Lord Justice Kay gave as an illustation the invention of a boiler in which the novelty was a number of pipes through which the fire might go. Perhaps a greater number than had ever been used before. It might be said in the patent that the draught must go through a chimney, and the size of this was described as 9in. square. It might be found afterwards that on a larger scale the area of the chimney must be greater. The inventor had not patented the chimney, but the boiler. Mr. Wallace interposed by saying that Mr. Lane Fox had not invented secondary batteries, and that, therefore, the illustration would not apply. Lord Justice Lindley said that there could not be effective distribution without some means of getting rid of that which had been distributed. Mr. Wallace said that if this hypothetical patent had been for a process of generating heat it would have been analogous to Lane Fox's patent. Lord Justice Kay said that it might be an invention for distributing heat in a boiler. They could not distribute if the passage were blocked.

SATURDAY, JULY 2ND.

Mr. WALLACE, in resuming his address on the cross appeal, said that when the Court adjourned they had been considering an analogy; he would not return to it, but would to a slightly different one. Suppose a steam engine, in which the steam, after passing out through the exhaust, was returned again into the engine. Anything which would stop the flow of steam could be injurious. This was the case with the earth. He then read extracts from the evidence about the use of the earth as a conductor. Mr. Wallace then turned to the absence of subject matter and anticipation. He said that the principle of parallel distribution was old, and that if Mr. Lane Fox would admit this he need not go on with this point. Mr. Lane Fox rose to say that there was not a word about parallel distribution in his patent. In so far as it was parallel it was not claimed. Mr. Wallace asked, what then was novel? It must be the use of batteries in connection with electric light. Lord Justice Kay said that it was for batteries used as reservoirs connected with lamps in parallel.

Mr. Wallace then turned to anticipation, and Lord Justice Lindley asked him how near he could come. Lord Justice Kay asked if there was anyone who had professed to keep pressure constant. Mr. Wallace said that there was no exact anticipation, but the examples he would give were to show the general knowledge on the matter before 1878. The systems of Clark, Breguet and others were mentioned. Mr. Justice A. L. Smith had dismissed these anticipations, but Mr. Wallace said that he was there to appeal against this. The patent of Achard was discussed, and Lord Justice Lindley said that, as far as they had got, there had been secondary batteries used as reservoirs for bells and brakes. Breguet's communication to *La Nature* was read, describing an arc light to be used at sea intermittently. Lord Justice Kay said that this was an approach, but a long way off Lane Fox. How much nearer could he get? Mr. Wallace then referred to Rapieff, and submitted that Lane Fox had made no invention. Lord Justice Lindley: "Although he succeeded in doing what nobody else had done?" Mr. Wallace: "But Lane Fox did *not* succeed." The defendants, he said, only used their battery to allow the station to be shut up at night. If they had no storage they would have to keep their staff there, and to keep the boilers, &c., at work all night, and in that case it would be impossible to earn a dividend. Lane Fox must have thought that his patent contained some further novelty, for he must have known that batteries had been used as reservoirs.

In dealing with the infringement, Mr. Wallace said that the real object of Lane Fox's invention was shown in Mr. Swinburne's diagram (*Electrician*, Vol. XXVIII., p. 548), particularly Case 3. Lord Justice Kay: "But that is construction," and added that he never allowed a witness to construe. Mr. Wallace said that it described what Mr. Lane Fox thought. Lord Justice Lopes: "You mean, what Mr. Swinburne thought Lane Fox thought," Mr. Wallace said that Lane Fox dotted his batteries about in order to reduce the size of the mains. Lord Justice Kay said that Lane Fox put certain things in the provisional, and when he came to the complete he recommended more. Mr. Wallace said that if he did that he smashed his lamps, spoiled his battery, with disastrous results.

When Mr. LANE FOX rose to reply, Lord Justice Lindley said that what they chiefly wanted to know was the exact nature of his invention, as everything would turn on that. Mr. Lane Fox said that he would do so, but would first say that he was going to deal with six points:—1. The nature and novelty of his invention. 2. The subject matter. 3. Utility. 4. Sufficiency. 5. Disconformity. 6, Infringement. He would first take the invention as described. The idea, he believed, was new. He wished for a source of power from which to distribute light, and with a variable number of lights, and yet have a constant available supply. He conceived the idea of a source of energy with which the current might vary, but the pressure remain constant, and this invention was a way of putting this into effect. The Edison patent for series lamps was subsequent to this patent, and it had been abandoned for further improvements. Edison's other patent was three weeks later than this, and was for a low-resistance lamp. Each was regulated independently. About one and a-half year later Edison patented the carbon filament This was on exactly the same lines as those suggested in his own patent, viz., high resistance, and the surface of the filament proportioned to the light to be given. The broad idea of his invention was the constant pressure. He did not rely on a generator and a steam-engine, and felt it was important to have some reserve, a kind of buffer, to equalise variations of pressure. Lord Justice Kay had suggested the analogy of a fire-engine in which an air cushion was used to give a constant stream. The Planté battery was well known, there was no need for him to describe it in his patent. A spring might be old, and yet might be applied to a novel purpose, but still it would take in force and give it out. If an inventor took a spring and a pendulum there might be no novelty in either; the action of a spring was well known, as, for example, in a bow and arrow, but these might be combined to form a clock; and the use of batteries in his invention differed as much from their former use as the spring of a bow differed from the spring in a clock.

Because an invention was simple it was not necessarily bad. It was well known that one could divide an electric current. An electric current used to be considered as a fixed quantity, and all efforts to divide it prior to his patent had been to split it up in the way in which the stream of a river divides round islands. But the idea of a constant pressure tending to develop currents was a new idea. He did not claim it as a principle, but he claimed means for carrying it into effect. His idea was that the pressure should be maintained, notwithstanding a draught upon the mains. He took high-resistance lamps and low-resistance mains. The battery was one means and the regulator was another.

Lord Justice Kay asked how Mr. Lane Fox distinguished current from pressure. Mr. Lane Fox replied that current was the result of a difference of pressure. Lord Justice Lopes asked a question about the hydraulic analogy, and Mr. Lane Fox expounded Ohm's law. Lord Justice Kay entered carefully on his notes from Mr. Lane Fox's dictation that current was proportional to electromotive force divided by resistance, and after that the matter of course dropped.

Mr. Lane Fox said that his invention was valuable by its simplicity, and cited a case in which a patent, though simple, was held to be good. Lord Justice Lindley observed that they were accustomed to simple inventions, and that Mr. Lane Fox need not deal with that. As to the practicability of return by earth, there were two distinct ideas. First, what is "earth"? and, secondly, how is it affected? He thought that there was no real disagreement here. "Earth" was a free path for the current. Telegraphists had for many years before this availed themselves of the conducting power of the soil. The term had thus become technical. He contended that *the* earth always meant the zero of potential. Lord Justice Kay asked if any known mode of return would do. Mr. Lane Fox proceeded to describe means of getting "earth." Sometimes telegraphists could not get it. If there were no earth at all, but dry sand, they could use a wire and call it "earth." If there was rock, earth-plates would not affect an "earth." If it were construed to mean soil, he would point to evidence which showed that 40 amperes would pass, and that that would be available for 100 or 200 lamps. On Fig. 5 of the specification (*The Electrician*, Vol. XXVIII. p. 438), there were less than a dozen lamps shown. That was only equivalent to four amperes. Dr. Hopkinson had admitted that it was possible to use 40. Lord Justice Lopes said that a skilled workman would know that if this failed he must use other means. Mr. Lane Fox said that "earth" meant a free path; if it were not a free path it would not be an "earth." Dr. Hopkinson's evidence showed that it would work on a small scale. He would not mind using 10 amperes; he would be uneasy with 100, and was positive that 1,000 could not be employed. Mr. Lane Fox compared these currents to the durability or

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life of the filaments of glow lamps. A durability of 1,000 hours is required and expected in lamps to-day. But lamps were made for the purpose of a patent case, some eight or nine years after the date of the patent, in which the life was from 2 to 60 hours. On this evidence that patent was held to be valid, and this life was held to be sufficient.

On the question of utility, Mr. Lane Fox wished to call attention to two distinct points with reference to secondary batteries. The first was that according to Mr. King they could not help to keep the pressure constant at all, but, on the contrary, they would cause variations where variations would not otherwise be. Mr. King had described this in connection with what he had been pleased to call an example of his (the plaintiff's) mode of working. It was a complete fallacy, for he used a constant current of a fixed quantity. Under cross-examination he had said that suppose there were no batteries at all, and that a constant current of 80 amperes was passing through the lamps, there might be a variation of three volts when half the lamps were turned off; but if batteries were connected, there would be more irregularity in the pressure which might become illimitable. Mr. King had been cross-examined by the Attorney-General upon a passage which had been inadvertently read by Sir Horace Davey from a circular issued by Mr. King's firm. In this passage the batteries were said to act as regulators. Referring to Rapieff's patent, it consisted of plates immersed in an insulating liquid, while Planté's battery contained a conducting liquid. The second point on the question of utility was that batteries had an inherent regulating effect, and not as Mr. King said. The defendants used a large store for commercial purposes, and in order to get their batteries full, they must raise the pressure. He would admit at once that they could charge them thus if they wished to do so, if they had got switches. They would then, naturally, not take care about high volts, and would not use large surfaces. Witnesses had admitted that a small current goes in under a small pressure. Prof. Forbes had done so with five volts. The batteries would have to be enormous for charging with a difference of only 1 per cent. It was true that they would have to go to the point B when they stored a large quantity. Mr. Lane Fox then repeated his analogy of storing gas in an iron bottle. There was no point at which it could be said to be full, and the same was the case with a secondary battery. When they charged and discharged with a large difference of pressure, there was a great waste of energy, and the commercial question was, Is it better to incur this waste, or to spend more on the first cost of a large battery. In Dr. Hopkinson's evidence he had said that his battery on one occasion had discharged for four hours and five minutes without moving the switches working on "Lane Fox pure and simple." Lord Justice Lopes interposed with the suggestion that there might have been no demand for regulation during this period. The question was the sufficiency of regulation by a large battery not fully charged. An extract from Sir F. Bramwell's evidence was read by Mr. Lane Fox, in which he described a battery which regulated within the limits of pressure prescribed by the Board of Trade, 4 per cent. up and 4 per cent. down. Mr. Wallace rose to point out that it had not been charged under these conditions. Mr. Lane Fox then dealt with the bubbling which is necessary to keep a battery in health, and said that Prof. Barrett had had his battery for six years, and the running of the lamps and charging of the battery had been carried on simultaneously. Mr. Lane Fox explained that batteries suffered from sulphating, and that this took place more with a thick active coating on the plate than with a thin one.

Mr. Wallace put in a written summary of his arguments.

MONDAY, JULY 4TH.

Mr. LANE FOX, in continuing his reply, began by recapitulating the chief points of his case, but soon broke the thread of his arguments to take up and reply to various statements in the summary which Mr. Wallace had put in on Saturday. He said that the defendants had been at great pains to prove that whatever size of battery was used, a great difference of volts was necessary for charging. He contended that the difference of pressure varied as the strength of the current, and had a relation to the surface of the plates. His evidence showed that when a large difference of potential was used to charge batteries, there was a great waste of power or energy. The more closely the voltage of charging and discharging approximated to each other, the more economical would be the working. This was well known to Planté. In speaking of charging with a large current, he did not mean a large current *per se*, but relative to the size of the battery or to the size of the installation. Within proper limits of plate area, they could charge and discharge with a small potential difference. It was admitted by the defendants that some current would go in and out. If he were not hampered by commercial considerations of storage, the batteries might be utilised to the best advantage. Sir F. Bramwell had said that the defendants could not earn a good dividend if they had gone to the expense of a battery five times greater than their present one. In Mr. Crompton's evidence it was stated that the defendants' batteries had 30 times as much active area as a Planté of the same size, but he did not want active area, but conducting surface. The point B, to which reference had so frequently been made, was only an imaginary point on a hypothetical curve. Mr. Crompton had said that this curve did not apply to his battery. There was no reason at all why 110 volts should mean 2·2 volts per cell. It might just as well be obtained by 55 cells at two volts each. It was said that the lamps would break at 110 volts, why not let the point be 100 volts, and use 100-volt lamps? But if there were any special virtue in 110 volts for the batteries, why not use 110-volt lamps? Why not keep both mains and batteries always more or less at 110 volts. According to the defendants' evidence the current would flow in and out readily at 110 volts; let them always charge and keep the batteries, then, at 110 volts, or use 45 cells and keep them at 100 volts. Referring to the summary handed in by Mr. Wallace, Mr. Lane Fox said he would reply to the statements contained in it. Lord Justice Lindley said that he had perhaps better conduct his case in his own way; and in reply to Mr. Lane Fox, Lord Justice Lindley said that he might draw up and put in a similar statement. On another suggestion that he need not attend further to this summary, Mr. Lane Fox said that he was not a bit afraid of it.

He said that Mr. Crompton had used 33 cells at the Law Courts and 59-volt lamps. The cells had been charged high, and they would have about 2·2 volts per cell, making 70 volts in all. These had been suddenly turned on to the 59-volt lamps, and, of course, they burned too bright. The brilliancy continued, according to Mr. Crompton's evidence, for about 20 minutes, or perhaps more. The high pressure did not, therefore, fall in a few seconds, as had been suggested. Mr. Wallace rose to say that they had dropped at once; the drop *had* taken place. Mr. Lane Fox referred to a discrepancy between the evidence of Prof. Kennedy and that of Mr. Millar. Prof. Kennedy had said that the cells regulated well with only a small variation in the number of the lamps; but Mr. Millar had said that they would not regulate at all with a small number, but would do so with a large number.

Continuing to comment upon disconnected points in Mr. Wallace's summary, Mr. Lane Fox said that the pressure was forced up in charging because a large current was being pushed in; the batteries became choked with it, and therefore the pressure became high. But if it were not pushed so rapidly the charging voltage would almost coincide with the statical voltage. Mr. Lane Fox alluded to the practical use of the present system of switches to Lady Conyers' ball, and remarked that switches were not used there, and he added that they were not used at the St. James' and Pall Mall station. He went on to explain and to discuss the chemical changes which went on in charging and discharging a battery. If the cell were empty, and there were only two or three volts right at the bottom of it, the resistance of that cell, Mr. Lane Fox said, would be very small. He again alluded to the storing of gas in an iron bottle under pressure, and said that if gas were compressed slowly there would only be back pressure; but if the pressure were rapid, there would also be friction, caused by the flow of gas in the pipe, and this was analogous to the internal resistance of the battery. He cited the aniline dye case, to show that the pecuniary success of an invention had no relation to its utility. After several disconnected references to points in Mr. Wallace's summary, Mr. Lane Fox said that the defendants infringed when the switches were standing in any position, and they only ceased to infringe while the switches were being moved. It was as though they infringed on the ground floor, infringed on the first floor, and infringed on the second floor, but not while they were going up and down stairs. It was easy enough, when the broad outline of an invention became known, to carry out modifications. The use of feeders was one such modification, and this was a subject of one of his own patents. He cited "Thomson *v.* Batty," an action for infringement of a patent of Sir William Thomson for ships' compasses. Long after these compasses—which were a God-send to sailors—had been invented, they were found wanting in a certain respect; but this did not prevent Sir W. Thomson from improving on his own patent. Mr. Lane Fox then drew their Lordships' attention to the last portion of Mr. Wallace's summary, and without reading it, said it was surprising that Mr. Wallace should not know about this matter, since he was a Director of the defendant Company. No evidence had been brought against him as to sufficiency. No experiments had been carried out to work the invention, as it had been described, to show that it could not be carried out; but evidence had been given to the opposite effect. He did not know if he had pointed out that in Ayrton's curves the largest current had been used that the manufacturers could recommend as advisable. Mr. Lane Fox concluded by thanking their Lordships for the consideration which they had given to his case.

Mr. WALLACE rose to offer some reply on the cross appeal, but was informed that nothing further was necessary.

Mr. LANE FOX asked if it were likely that judgment would be given soon, as he had a petition before the Privy Council for an extension of his patent.

Lord Justice LINDLEY said that the judgment could not be given sooner than a fortnight.

Lane-Fox Petition before Privy Council for Extension of Patent.

Mr. St. G. Lane Fox's petition for prolongation of his patent rights (No. 3,988, 1878) came before the Judicial Committee of the Privy Council on Thursday.

The petitioner appeared in person. Mr. Wallace was counsel for the respondents (the opposers); and Mr. Sutton represented the Crown.

At the commencement of the proceedings it was pointed out to the petitioner that he had failed to lay before the Committee detailed accounts showing the amount of remuneration which the patent had brought to him from every point of view.

Mr. LANE FOX replied that he could call evidence on that point, and asked their lordships not to confine themselves very strictly as to the details in connection with the accounts. He said he had derived no advantage from his invention, although it was admitted that large industries had grown up out of it.

The opposers called attention to the fact that the patent had been declared invalid in the Court of Chancery; but the Committee replied that they were not concerned with the validity of patents.

After some discussion the Committee decided that inasmuch as Mr. Lane Fox had failed to produce the proper accounts showing the amount of remuneration he had derived from his patent during its eight years' working, and that being an indispensable condition which had been imposed on persons seeking an extension of their patent rights, the petition must be dismissed.

The petition was accordingly dismissed.

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In re Joseph Slater Lewis.

The public examination in bankruptcy of Joseph Slater Lewis, described as an electrical appliances manufacturers' manager, of Middlesex, and lately carrying on business at the National Telegraph Works, Wainwright-street, Aston, and residing at the Swifts, Yardley, was fixed to take place at the Birmingham County Court, on Thursday last week, before Mr. Registrar Cole. The liabilities were stated at £1,613. 18s. 7d., and assets *nil*. Mr. J. A. Etches (Whitchurch) represented the bankrupt; and Mr. Hugo Young (instructed by Mr. Isaac Bradley) appeared for Messrs. Archdale and Co., the petitioning creditors.

Mr. WOOLLETT (the Assistant Official Receiver) applied for an adjournment, as certain accounts had not been filed, and an investigation of them had consequently not been made.

Mr. ETCHES opposed the application, remarking that he understood the Official Receiver did not find fault with the accounts not being filed, but the bankrupt had not separated the private from the trade accounts. He should at all events like to ask the bankrupt certain questions, which he wished to be brought before the Court, in reference to his failure.

The REGISTRAR pointed out that the accounts were not only supposed to be filed for the convenience of the Official Receiver, but also that any creditors might inspect them.

Mr. WOOLLETT said he thought a week would be ample time.

Mr. ETCHES: Then there is the election, and I could not attend here.

The REGISTRAR: This Court has nothing to do with the election—(laughter).

The bankrupt said he desired the matter over as quickly as possible, for certain things were hanging over his head which were acting to his very serious prejudice.

Eventually it was decided that the examination should be adjourned until July 25th.—*Birmingham Gazette.*

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *June* 25, 1892.

Among the smaller Swedish towns adopting the electric light is Helsingborg, which has just erected a central electric station, close to the new harbour. The full capacity is estimated at 2,000 16-c.p. lamps, although the plant at present installed only amounts to 100 H.P. The three-wire system is employed, without accumulators. The cables are underground, and are of the Siemens and Halske iron-hoop protected lead-covered pattern.

The State Telephone in Sweden has issued its seventh list. There are now 5,604 subscribers, against 3,176 subscribers in its former list of July 1st last year, showing an increase in ten months of 2,428 subscribers. The Christiania Telephone Company last year increased its number of subscribers by 376, the total of telephones in use at the end of 1891 being 3,280, as against 2,817 the year before. During 1891 4,682,843 conversations were held through the Christiania exchange, being 1,428 conversations per subscriber per year, the average for week days being 15,136. A new telephone tower has been built, with accommodation for some 4,000 aerial wires and about 5,000 cables. The receipts amounted to 254,208kr., against 222,397kr. last year. The net profits were 69,000kr., of which the shareholders get 6 per cent. The share capital has now been doubled, and amounts to 1,500,000kr.

The electric lighting of the principal square of Copenhagen has now been completed, and works exceedingly well. The standards for the arc lamps are very ornamental, although they cannot vie with those placed at a portion of the pier, which are very elaborate. At the recent illumination on the occasion of the Golden Wedding of the King and Queen of Denmark, a number of temporary electric light arrangements were installed, and gave universal satisfaction.

CORRESPONDENCE.

NEGATIVE RESULTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With the general tenour of your remarks on page 209 I, of course, agree; but there are just one or two details which it may be worth while to emphasise.

You question whether we can ever induce nature to say "no." If we ask unreasonable questions it may, indeed, be impossible; but if we ask reasonable ones, it is easy to get a definite answer. To the question, "Does light travel as slowly as sound or bullets?" the ancient experiment with dark lanterns could readily reply, "No, very much quicker." To the question, "Does light travel at an infinite pace?" it could answer nothing. The question, "At what rate does light travel?" it could not answer; but that is not a question to be answered by either yes or no.

I submit that "a measure of magnitude, however rough," is not always and necessarily more satisfactory than a definite failure to find any magnitude to measure. For if the possible error is 100 per cent., we may very possibly be seeming to measure something which is really non-existent.

Thus, in the early part of the century many attempts were made to determine the parallax of the fixed stars, and many apparent results were obtained. But the more care taken the smaller these results became, and some of them gave a parallax less than nothing, making the stars further than infinity!

Again, before the time of Bradley it was comparatively easy to get apparent parallactic observations of zenith stars; but they were spurious, and were shown by Bradley to be spurious, being due to the finite velocity of light and to an undiscovered motion of the earth's axis. Their periodicity (one year and 19 year periods) in this instance distinguished them from the genuine phenomenon; which last indeed is now observable, although so extraordinarily minute (half a second at most). It must, I think, be admitted that, under these circumstances, a definite failure to detect any parallax so great as one second of arc would have been a result more valuable and more difficult to secure than a "measurement of its magnitude, however rough" (say two or three seconds out).

Similarly with regard to the possible drag of ether by matter. If the question asked is "Does moving matter drag ether infinitesimally with it?" that cannot be answered. But if the question asked be, "Does a moving sheet of steel drag ether a tenth of an inch away from it with its own speed, or with as much as one-tenth of its own speed?" experiment has answered, "No, nor yet with as much as one-hundredth of its speed." And the difficulty was to secure this negative result. It was easy enough to get positive results; results, moreover, of reasonable, and by-some-expected magnitudes; but all these had to be hunted down and traced to their several spurious sources before it could be clearly asserted that the answer, down to a certain finite limit of accuracy, was in the negative. To expect an infinite accuracy in the answer 0 is as unreasonable as to expect an infinite accuracy in an answer like 52,871.

I do not think that anything I have said is of the nature of controversy. I write because I am glad of the opportunity you have kindly afforded me to remove so far as possible what seems to me a slight misapprehension, which appears rather prevalent, concerning the value of a definite and specific and numerical "negative answer."—Yours, &c. OLIVER J. LODGE.

THE "AMPERE-CENTIMETRE."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of June 3rd you reprint my Paper on the "Ampere-Centimetre, a Measure of Electromagnetism," to which you have added some interesting and able editorial comments on page 113. It seems to me, however, that your criticisms in the third paragraph on page 108 are very unjust, and even incorrect, as will appear evident from your two subsequent paragraphs, and from the original Paper. You say that the "error" in my argument lies in the assumption that K is a constant. It appears, however, that K *is* a constant for circles (and therefore also for a straight line or infinite circuit), which is the only sense in which I use it; and I stated this clearly in the article. It was a mistake on your part to assume that I applied K to anything but a circle. You say it "varies very much for different sizes and shapes of the circuit." It does *not* vary at all with the size of the *circle*. It is, of course, not constant for different *shapes* of circuits, that is, different from a circle; but nowhere did I assume it was. I am well aware that the self-induction of the circuit changes with its shape, and nowhere do I say or assume the contrary. It would not have been an unwarranted assumption on your part to have assumed that I knew this. I admit that it was an unfortunate oversight on my part not to have added the word "circular" before "circuit" or coil in the sixth paragraph of my Paper, but it seems to me this might have been inferred from the rest of my Paper. Magnet coils in practice are usually circular, or nearly so, and my remarks had reference to such coils; but I admit it ought to have been more clearly stated.

In the same paragraph you speak of the effect of iron in varying this constant K. This is clearly met in the first part of my Paper. You also state that "it is quite erroneous to

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assume that the number of lines of force produced by the current flowing in a circuit is proportional to the number of amperes multiplied by the number of feet of wire composing the circuit." While in the very next paragraph you show that the conditions under which it does hold "are all very nearly fulfilled in the manufacture of any given type of machine." If this second statement is true, the first is certainly not just or fair criticism, at all events it does not seem consistent on your part. If the Paper is worthy the favourable comment you make, it would hardly seem to deserve the condemnation which you give in such superlative terms.

The intention of my Paper was to endeavour to prove, or at least to start a discussion which would prove or disprove the fact that a unit current, considered apart from its return path or from magnetic material, represents a fixed and definite number of lines of force for every unit length of its path. When a circuit is doubled on itself, as it always is in any closed circuit, there will be a joint action of two opposite circuits, which action will evidently depend on the relative positions of the parts of the circuits. I merely thought that by starting with the ampere-centimetre as a sort of unit, some problems in electromagnetism might possibly be simplified. Furthermore, the principle announced does seem to be true for circular coils, and as most magnet coils are circular or nearly so, it might be applied to most of the practical cases, as you yourself have shown. My object was merely to make a suggestion, hoping it might be of use to someone.—Yours, &c., CARL HERING.

June 18, 1892.

[We still think our former criticisms fair. We never supposed our valued correspondent to be ignorant of the fact that the self-induction of a coil is dependent on its shape. It is, however, quite possible to be aware of a fact, and yet to argue in a manner which can be shown to be inconsistent with it. The two quotations in the above letter in no way contradict each other. Some further comments will be found in our "Notes" column.—ED. *E.*]

SUSPENDED *v.* STATIONARY COIL GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 1st there is a letter by a Mr. Flower which ends as follows:—"Comparing these figures with the results given above, the immense superiority of the Thomson over the d'Arsonval galvanometer (as far as sensitiveness is concerned) is obvious. The statement made concerning the latter instrument is, therefore, utterly misleading, to say the least of it." Probably your readers will have already detected the collection of errors in Mr. Flower's letter which have led him to this conclusion; but, as he has been so ill-advised as to base a grave charge on his incorrect reasoning, it may be advisable to place his errors on record.

He quotes our statement that a certain d'Arsonval galvanometer of 300 ohms resistance gave a deflection of 95 divisions per micro-ampere on a scale placed at a distance of 2,000 scale divisions. To this statement he raises no objection; but he says that, from tests he has made, a Thomson galvanometer constructed by Messrs. Elliott, and having the same resistance and a periodic time of 4·5 seconds, would give the same deflection with $\frac{1}{110000}$ ampere, and he deduces from this "the immense superiority of the Thomson over the d'Arsonval galvanometer." Is this because he does not know that a micro-ampere means the millionth of an ampere, or can it be that he is not aware that $\frac{1}{1000000}$ and $\frac{1}{110000}$ only differ by one-tenth part?

But had these two instruments the same periodic time? No; the periodic time of the Thomson galvanometer was 4·5 seconds, while that of the d'Arsonval galvanometer, as stated on the label attached to this instrument, was 4 seconds. (The 5 seconds attributed to this instrument by Mr. Flower is a mere assumption.) Consequently, had the Thomson galvanometer been adjusted to have the same periodic time as the d'Arsonval galvanometer, the current of $\frac{1}{110000}$ ampere, given by Mr. Flower, would have been increased to $\frac{1}{87000}$ ampere, which is, actually, 15 per cent. greater than the one micro-ampere required by the d'Arsonval instrument.

We may, however, go even farther than this; for, as stated in the Abstract (see *The Electrician*, page 175) the decrement is *13 on open circuit*—that is to say, the second swing is only one-thirteenth of the first, or this instrument is practically dead beat *even on open circuit*. Now this damping lengthens the periodic time by about 33 per cent., so that if the silver damping tube attached to the coil were replaced by one of manganin the periodic time would become only 3 seconds instead of 4. If, then, the two instruments be arranged for equal damping as well as for the same resistance of 300 ohms and the same periodic time, the d'Arsonval instrument has not merely the same sensibility, but a far greater sensibility than that possessed by a 300-ohm Thomson galvanometer as given by Mr. Flower.

In what way, however, has Mr. Flower ascertained the sensibility of a 300-ohm Thomson galvanometer when the periodic time is five seconds? Why, by using the following startling law:—"In Thomson instruments of similar construction their figures of merit are fairly proportional to their resistances." Consequently, the resistance of a coil of given volume is proportional to the number of turns it contains. We thought that even a tyro knew better than this.

As a matter of fact, the sensibilities of galvanometers of similar construction, and adjusted to have the same periodic time, are about proportional to the square roots of their resistances when these resistances are low, and to their resistances raised to the power two fifths when high; (*see* our Paper on "Galvanometers," p. 92, *Proc. Phys. Soc.*, July, 1892). Mr. Flower is, therefore, but a sorry champion of the Thomson galvanometer, for he has much understated its sensibility. Indeed, if his tests of the 1,830-ohm instrument may be taken as correct, a 300-ohm Thomson galvanometer will be about three times as sensitive as his erroneous calculation makes it out to be.

Well, at any rate, he will say, even if my calculations be all wrong there is still something in my statement regarding "the immense superiority of the Thomson over the d'Arsonval galvanometer." Unfortunately for Mr. Flower, even when the Thomson galvanometer is credited with its true sensibility, and not with the smaller sensibility that Mr. Flower calculates for it, his sweeping statement remains just as untrue when equal damping as well as equal resistance and periodic time are considered. And in case he may not realise the correction that has to be made for damping we would refer him to the performance of the undamped d'Arsonval galvanometer that we also exhibited at the meeting of the Physical Society, but to which Mr. Flower makes no reference. This instrument has 13 ohms, a periodic time of 2·7 seconds, and gives a deflection of 74 scale divisions per micro-ampere. Now let us compare with this, not the sensibility erroneously calculated by Mr. Flower for a 300 ohm Thomson galvanometer, but the actual result which he says he obtained with an 1,830-ohm instrument. The periodic time was 4·5 seconds, and a deflection of 90 scale divisions was obtained with $\frac{1}{7340000}$ ampere. Hence, if this instrument were wound so as to have a resistance of 13 ohms, and if the controlling magnet were adjusted so that the periodic time were 2·7 seconds, it would give for one micro-ampere a deflection of

$$7{\cdot}34 \times 90 \left(\frac{13}{1830}\right)^{\frac{2}{5}} \left(\frac{2{\cdot}7}{4{\cdot}5}\right)^{2}$$

that is, 33 scale divisions.

Hence this d'Arsonval instrument is about $2\frac{1}{4}$ times as sensitive as Mr. Flower's "immensely superior" Thomson galvanometer.

It is to be observed that in selecting the power $\frac{2}{5}$ in preference to $\frac{1}{2}$ we have employed the power most favourable to the Thomson galvanometer, since, if the power $\frac{1}{2}$ had been used in the calculation given above, the result would have been that one of the d'Arsonval galvanometers exhibited by us at the Physical Society was nearly 4 times as sensitive as the Thomson instrument tested by Mr. Flower.—We are, &c.,

W. E. AYRTON.
T. MATHER.

TESTS OF TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the remarks in this week's number of *The Electrician* in reference to Dr. Hopkinson's transformer tests, it is stated that some of the transformers give an efficiency of 85 per cent.

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at quarter load, and 97 per cent. at full load. The further statement is then made that these transformers, when working at full load for six hours and open circuit for eighteen hours, give a day efficiency of 92 per cent. "This," it is added, "will occasion surprise."

I must humbly confess it has very much surprised me, as it is obvious that, if the above statement is correct, there must be less waste in a transformer when open circuited than when it is at quarter load. I am sure that if this could be demonstrated all the alternating-current supply companies would be highly delighted, since at present they are mostly suffering from the idea that the opposite is the case.—Yours,

London, June 30, 1892. R. N. LUCAS.

CARBON BRUSHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I observe in the last number of your journal an article dealing with carbon brushes for dynamos; and you seem to draw the conclusion that whilst they are widely used on the Continent, they have up till the present met with little favour in England. On the contrary, I can assure you that I have exported to England, through the agency of Mr. N. G. Thompson, of 13, Victoria-street, considerable quantities of these brushes; and I am in a position to state that English manufacturers have used them with success, since trial orders have invariably been followed by others of greater importance.

The objections which you offer to their general use, founded on the changes necessary with the old types of machines, are in the main perfectly fair but unimportant when we consider the small expense incurred and the results obtained.—Yours, &c.,

Paris, July 4, 1892. J. A. BERNE.

[The fact still remains that we sent a representative to the Crystal Palace Exhibition for the express purpose of examining and reporting upon the dynamo brushes, and that he failed to see a single specimen.—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the paragraph in your issue of June 24th relating to carbon brushes, we fully endorse your remarks on the subject. It may interest you to know that we have used carbon brush gear on a very large number of our motors during the last two years, and in every case it has given satisfaction. We have found carbon superior to any other description of brush for motors requiring frequent reversal, having applied them successfully to tramcar, launch, crane, winding gear, and other motors.—Yours, &c.,

THE GENERAL ELECTRIC POWER AND TRACTION CO. (LIMITED),
THOS. SMITH, Secretary.

New Broad-street House, 35, New Broad-street,
London, July 6, 1892.

[Our remarks on this subject were not intended to be very laudatory; but, as they have called forth so many comments, we should be glad to hear if carbon brushes have ever been used to carry as much as 100 amperes, and to learn the dimensions necessary for collecting this current without heating.—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have used carbon brushes from Levallois Perret on two installations I put up for my firm, one a King Brown, and the other a Crompton dynamo. In both cases they have answered perfectly, and kept the commutator in beautiful condition. Nor have I found the trouble you suggest in their current-carrying capacity. We also use them on a small Siemens at our works.—Yours, &c., RUSSELL.

Maidenhead, July 6, 1892.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.—The tenth annual edition of the above well-known annual is on sale, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (a few countries excepted), post free, 8s. 10d. A digest of the contents will be sent on application.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Committee of the Co-operative Wholesale Society (Limited) announce in our advertisement columns that they are prepared to receive tenders for the electric lighting of their warehouses and offices in Waterloo-street and Thornton-street, Newcastle-on-Tyne. Specifications and all information can be obtained from the society's engineer, Mr. John Thompson, C.E., Post Office-chambers, Newcastle. Tenders are to be delivered at the society's offices, Newcastle-on-Tyne, or or before the 19th inst.

———The Lighting Inspectors of Watlington (Oxon) invite tenders for lighting streets, roads, and other places in the parish either with oil, gas, or any other material. Tenders should be sent at once in a sealed letter, addressed to Mr. Richard Spyer, the Treasurer, at the office of the Inspectors, Market-p'ace, Watlington, of whom particulars may be obtained.

TENDERS RECEIVED.—The following were the tenders received by the Southampton Harbour Board for the supply of two electric cranes:—

	Cranes.	Accessories, mains, &c.	Total.
Keys' Electric Company (Limited).	£2,700	... £1,175	... £3,875
Crompton and Co. (Limited)	3,209	... 234	... 3,443
J. G. Statter and Co.	2,100	... 287	... 2,387

As mentioned in the last issue of *The Electrician*, p. 235, the tender of Messrs. J. G. Statter and Co. was accepted.

APPOINTMENT VACANT.—The Corporation of Blackpool invite applications for the appointment of a resident electrical engineer in connection with the scheme of electric light installation. Applications must reach Mr. T. Loftos, the town clerk, on or before Wednesday, the 20th inst. Further particulars will be found in our advertisement columns.

BARNET.—Messrs. H. F. Joel and Co. inform us that the award in the arbitration between themselves and the Barnet Local Board, in which they claimed compensation for breach of contract, was taken up by them on Friday last, June 30th, and was entirely in their favour. They obtain £500 as damages, and their costs in the reference, and the costs of the award.

PERSONAL.—Messrs. Fuller and Tate, late of the Brush Engineering Company, have gone into partnership, and commenced business at 20, Bucklersbury, as electrical and mechanical engineers.

VAUGHAN-SHERRIN ELECTRICAL ENGINEERING COMPANY (LTD.).—Claims against this Company (in voluntary liquidation) must be sent to the liquidator, Mr. S. Hedges, 15, George-street, Mansion House, E.C., by the 29th inst.

ELECTRIC APPARATUS COMPANY (LIMITED).—A meeting of the shareholders in this Company (in voluntary liquidation) will be held at Mr. John Annan's, 1, Walbrook, E.C., on the 8th prox, at 11 a.m., to receive an account of the winding-up.

DEED OF ASSIGNMENT.—A deed of assignment for the benefit of his creditors was filed on the 1st inst. by Herbert William Hooper, electrical engineer, of 17, Princes-street, Hanover-square, London, W., and Rowland Lodge, Epsom. The secured liabilities are £300, and unsecured £967. 12s. 6d.; and the assets, after deducting secured claims, are set down as £615. 6s. 6d.

LE CARBONE.—A company with this title has been formed to acquire the business of Messrs. Lacombe and Co., carbon makers, of Levallois-Perret, near Paris.

BENHAM AND FROUD (LIMITED).—To celebrate the jubilee of Mr. Froud's connection with the well-known Chandos Metal Works (which were established so far back as 1785), the chairman of the Company invited the directors and a select party of gentlemen immediately connected with the company to dine at the Crystal Palace on the 30th ult., the occasion forming also a pleasant termination to the labours of some of their number in connection with the Electrical Exhibition. By a coincidence one of the braziers in the employ of the firm also attains his jubilee of work this month, and the event was fittingly marked by a presentation during the afternoon.

COLLIERY LIGHTING.—The General Electric Power and Traction Company (Limited) have received instructions to light the New Hemsworth Colliery, near Halifax. The plant consists of a 300-light dynamo, and the necessary wiring and fitting.

ELECTRIC WIRES AND CABLES.—Messrs. W. T. Glover and Co send us a very well-arranged price-list of their manufactures, including vulcanised wires and cables, lead-covered, concentric, and armoured cables, flexible cords for ship use, twin flexible, and wire for fittings, flexible cable for dynamos, fuse and jointing wire, &c. They introduce a system of reference numbers, which seems to offer some advantages. 71653, for example, means 7 strands of No. 16 gauge of class No. 53. Various tables and formulæ make this a very useful catalogue.

ELECTRIC LAUNCH.—The "Florentia," an electric launch, by Mr. Sargeant, had her trial trip at Twickenham last Friday.

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PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

June 16, 1892.

11,277. G. A. GOODWIN and H. FOSTER. London. Improvements in electric current meters.

11,302. F. H. NALDER, H. NALDER, C. W. S. CRAWLEY and A. SOAMES. London. Improvements in electrical measuring instruments.

11,316. G. W. VIANEN. London. Improvements in or connected with electric alarums.

11,320. C. VOGT. London. Improvements in telephonic apparatus.

11,326. R. H. COURTENAY. London. Improvements in tubes or pipes for aeration drainage and electrification for horticultural purposes.

June 17, 1892.

11,344. F. B. NICHOLSON. London. Improvements in casing for cables and wires.

11,353. D. J. MULLAKY. Bradford. Improvements in electrical alarum clocks.

11,382. H. NIEWERTH. London. An improved process for manufacturing compound and elementary bodies or chemical products by means of electricity, and apparatus therefor.

11,393. F. WYNNE. London. Improvements in or relating to electric railways.

11,403. W. T. GOOLDEN and L. B. ATKINSON. London. Improvements in electric generators and motors.

June 18, 1892.

11,424. G. C. DYMOND. Liverpool. Improvements in automatic telephone and other electric exchanges. (Almon B. Strowger, United States.)

11,426. G. C. DYMOND. Liverpool. Improvements in or relating to indicating electric switches and current reversers. (Almon B. Strowger and W. S. Strowger, United States.)

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

11,113. LAHMEYER. Electromotors, &c.

12,525. GRIMSTON and DYKES. Electrical steering gear.

13,250. WHEATLEY (Ashfalck). Electrical switches, &c.

13,331. KELLOGG. Telephony.

1892.

5,631. JOHNSON (Hiss). Electrically-controlled elevators.

6,722. DONALDSON and MACRAE. Secondary batteries.

7,415. DEWEY. Electric propulsion of vehicles, &c.

8,535. FOWLER. Electrical hose-signalling apparatus.

COMPANIES' MEETINGS & REPORTS.

India Rubber, Gutta-Percha and Telegraph Works Company (Limited).

The half-yearly general meeting of this Company was held yesterday at the Cannon-street Hotel; Mr. S. W. Silver presiding.

The SECRETARY (Mr. William J. Tyler) having read the notice calling the meeting,

The CHAIRMAN said: I take the opportunity of informing you that the issue of new shares referred to when we last met has been satisfactorily carried out. This addition of capital, which was readily taken up, has greatly strengthened our position. The amount of general sales was increasing. We have manufactured and despatched the cables, and the ss. "Silvertown" is now off the coast of Brazil, engaged in laying the cables across the Atlantic to the West Coast of Africa. I may add that the works, machinery, &c., are in excellent order and equal to any demand that may be made. I beg to move, in accordance with the notice calling the meeting,—

"*That an interim dividend of 5 per cent. be paid forthwith.*"

The MANAGING DIRECTOR (Mr. Matthew Gray) seconded the motion, which was carried unanimously without discussion.

Mr. TREBLE moved, and Mr. MARTINDALE seconded, a vote of thanks to the Chairman and Directors, which was cordially passed.

The CHAIRMAN, in returning thanks, said that this renewed mark of confidence on the part of the shareholders would tend to increase the efforts of the Board to promote the prosperity of the Company.

The proceedings then terminated.

National Telephone Company (Limited).

The following is the report of the Directors for the year ending April 30 last, to be presented to the shareholders at the twelfth ordinary general meeting of the Company, to be held at the Cannon-street Hotel, on Thursday next, 14th inst., at 12 o'clock noon:—

The income accrued in respect of the business of the year amounts to £463,741. 5s. 4d., as compared with £431,112. 11s. 11d, for the preceding year, being an increase of £32,628. 13s. 5d.

The working expenses and other charges (excluding debenture and other interest) amount to £236,252. 0s. 5d., as compared with £199,483. 15s. 8d. for the preceding year, being an increase of £36,768. 4s. 9d.

The net result for the year, after deducting the Post Office royalties, amounting to £40,239. 5s. 8d., is a profit balance of £187,249. 19s. 3d., as compared with a balance of £195,047. 3s. 11d. for the preceding year, being a decrease of £7,797. 4s. 8d. It must, however, be remembered that at the end of 1890, in view of the expiration of important patents, a reduction of the tariffs in most of the Company's districts was carried into effect. Upon the business of the past year, this reduction has been equivalent to a cession of about £55,000 to the subscribers.

Further attention may be called to the fact that the rentals carried forward this year for unexpired terms of running contracts amount to £234,370. 11s. 2d., as compared with £204,431. 15s. 4d. for the preceding year, or an increase of £29,938. 15s. 10d.

Out of the divisible balance, after providing for interest on Debenture Stock, an interim dividend for the first half-year has already been paid at the rate of 6 per cent. per annum on the first and second preference shares, and 5 per cent. per annum on the ordinary shares. The Board will recommend the payment of a further dividend for the last half-year at the rate of 6 per cent. per annum on the first and second preference shares, and 7 per cent. per annum on the ordinary shares, making, with the interim dividend, 6 per cent. for the year.

The Board propose, under Article 113 of the Articles of Association, to transfer to reserve account £10,000, which, with £1,127. 3s. 6d. placed to reserve during the year from premium account, will bring up the amount of the reserve fund to £104,627. 3s. 6d.

The Directors have acquired on advantageous terms the telephonic business of the Caledonian Telephone Company (Limited) and of the Sheffield Telephone Exchange and Electric Light Company (Limited). A provisional agreement has also been recently entered into for acquiring the undertaking of the Western Counties and South Wales Telephone Company (Limited).

The Government have recently determined upon a policy under which it is proposed that all the trunk lines used for inter-town telephonic communication shall become the property of and be worked by the State, the exchanges and local service remaining in the hands of the companies for the term of their present licences. An Act confirming this policy and granting the necessary powers has just been passed by Parliament. Under its provisions the trunk lines of this Company can be acquired by agreement for money payment and other adequate compensation. The Board, after much anxious consideration, have decided that, as licensees of the Postmaster-General, it will be their duty, on fair terms, to co-operate loyally with him in giving effect to a policy having for its express object the expansion and improvement of the telephone service of the Kingdom, hitherto so seriously hampered and retarded for want of sufficient legal powers for carrying out such works as are absolutely essential if efficiency is to be attained. With this object in view, negotiations with the Government are now pending.

Since the last annual meeting the Company has suffered a severe blow in the death of its late President, Mr. F. R. Leyland. His colleagues on the Board desire to express their sense of the great loss which they have sustained by his death in being deprived of a valued coadjutor and friend. To fill the vacancy thus caused the Board have appointed Mr. George Franklin, of Sheffield, as a Director, with a view of securing representation on the Board of one of the most important commercial centres of the undertaking. The magnitude of the Company's business has rendered necessary the appointment of a general manager, and the Board have secured the services in that capacity of Mr. W. E. L. Gaine, who resigned the office of Town Clerk of Blackburn to take the position. The following Directors retire at this meeting, and being eligible offer themselves for re-election, viz., Mr. James Staats Forbes, Colonel Robert Raynsford Jackson, Mr. Eli Heyworth, and Mr. Samuel Herrick Sands. The auditors, Messrs. Welton, Jones, and Co., also retire, and are eligible for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

BRYNCELYN (PONTARDAWE) GASLIGHT AND COKE COMPANY (LIMITED).—This Company was registered on the 30th ult., with a capital of £1,500, in £10 shares, to light the parishes of Llanguicke and Killyhe bill, in the county of Glamorgan, with gas, electricity, oil or other illuminating power; to acquire, construct, maintain and work the necessary plant, engines, machinery and appliances, for making, generating, storing, accumulating and distributing gas and electricity; and to manufacture, sell and deal in lamps, brackets, globes, burners, meters, galvanometers, ammeters, voltmeters, carbons, cutouts, switches, motors, batteries, &c.

ELECTRIC LAMP COMPANY (LIMITED).—This Company was registered on the 28th ult., with a capital of £4,000, in £1 shares. The objects are to carry on the business of an electric light company in all its branches, electricians, electrical and mechanical engineers, suppliers of electricity, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity.

HOLLOWAY ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company was registered on the 30th ult., with a capital of £2,000, in £10 shares. The objects are to purchase, take on lease or otherwise acquire and to establish and maintain central and other stations, from which electricity may be supplied; to carry on, in the parish of Islington, or elsewhere, the trade or business of electric lighting in all its branches, to obtain any Act of Parliament or any Provisional Order or licence of the

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Board of Trade or of any municipal or local authority for enabling the Company to carry any of its objects into effect, and to manufacture, deal in, or let out on hire instruments, appliances, plant, or apparatus for producing, storing, distributing, supplying, using, regulating, or measuring electricity. The subscribers (with one share each) are Sidney Sharp, 34, Victoria-street, S.W., engineer; J. M. Kent, 34, Victoria-street, S.W., engineer; E. J. Piper, 4, Tollington-road, Holloway; P. W. Rands, 5, Boswell-road, Croydon; C. P. Heap, 60, Waldegrave Park, Strawberry-hill, engineer; H. A. Folkard, 9, Ormiston-road, Uxbridge-road, W.; G. W. Harrow, 4, Lonsdale-square, Barnsbury, N. The Directors may purchase or otherwise acquire and undertake, upon such terms and conditions as they think fit, the business or businesses of a central electric lighting station and electrical engineers and contractors, now carried on by Messrs. Sharp and Kent, at Tollington-road and elsewhere in the parish of St. Mary, Islington. The number of Directors is to be not less than three nor more than seven, the first to be elected by the signatories. Qualification, £500; remuneration, as the Company in general meeting determine.

HOPE-JONES ELECTRIC ORGAN COMPANY (LIMITED).—This Company was registered on the 1st inst, with a capital of £25,000, divided into 1,200 preference and 1,300 ordinary shares of £10 each. The objects are to acquire certain letters patent, inventions, businesses, and premises, set forth in an agreement dated June 30, 1892, between Robert Hope-Jones, electrician and engineer, of 55 and 57, Argyle-street, Birkenhead, of the one part, and Frederick B. Townsend (on behalf of this Company) of the other part; to apply electric and pneumatic apparatus to organs and other musical instruments; to carry on business as builders and manufacturers of organs and other musical instruments, and as electricians; and to manufacture, sell, and deal in electric, pneumatic, and other apparatus. The first Directors are:—Thomas Threlfall, G. A. W. Beard, William Creser, W. D. Hall, and Robert Hope-Jones.

RAILWAY ELECTRIC READING LAMP COMPANY (LIMITED).—This Company was registered on the 4th inst., with a capital of £100,000, divided into 16,000 ordinary and 4,000 deferred shares of £5 each. The objects are to purchase from the Railway Automatic Electric Light Syndicate (Limited) the patents for the United Kingdom for electric reading lamps, granted to Dixon H. Davies and John M. Tourtel, which are referred to in the draft of an agreement which it is intended to enter into between the said Syndicate of the first part, John M. Tourtel and Dixon H. Davies of the second part, and the Company of the third part; to take over the benefits and obligations of an agreement dated May 27, 1892, between the Metropolitan District Railway Company of the one part, and the Railway Automatic Electric Light Syndicate (Limited) of the other part, and to enter into an agreement with the Metropolitan District Railway Company, by which the Company will be authorised to instal and work automatic electric reading lamps in carriages of the said Railway Company; and to manufacture, construct, use, sell, let, or otherwise deal with electric lamps, for use in railway and other carriages, steamships, reading rooms, tramcars, &c. The subscribers (with one share each) are Benjamin H. van Tromp, Emile Garcke, Edmund Etlinger, W. H. Fox, J. Cecil Bull, John M. Tourtel, and Frederick C. Cocking. The first Directors are Edmund Etlinger, John H. Kincaid, Charles E. Spagnoletti, and Benjamin H. van Tromp, Qualification, 50 shares; remuneration, £800, and in each year in which a dividend of £7 per cent. per annum has been paid, £5 per cent. of the excess, the said remuneration to be divided as they themselves determine.

MISCELLANEOUS. — Chemists' Association (Limited), wholesale chemists; capital, £50,000, in £1 shares.——Hotel Belgravia (Limited), hotel proprietors and producers and suppliers of electricity; capital, £60,000, in £5 shares.——Thomas Piggott and Co. (Limited), electrical and mechanical engineers; capital, £90,000, in £10 shares.

BLOCKLEY ELECTRIC LIGHTING AND MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, made up to June 13th, was filed on the following day. Out of a capital of £20,000 in £5 shares, 461 ordinary and 67 £5 per cent. preference shares have been taken up, and the full amount called, resulting in the payment of £2,640.

EVERED AND CO. (LIMITED).—The annual return of this Company, made up to April 14th, was filed on June 3. At the time of making-up 16,496 shares had been taken up, and upon 6,744 of these the full amount had been called, and upon the remaining 9,752 shares a call of £7 per share had been made, resulting in the total payment of £135,704.

GREENWOOD AND BATLEY (LIMITED).—The annual return of this Company, made up to June 24th, was filed on the 30th. At the time of making up, 11,066 preference and 18,052 ordinary shares had been taken up, of which 2,666 preference and 4,666 ordinary shares had been issued as part payment of the purchase consideration. Upon 9,600 preference and 16,800 ordinary shares (which numbers include the shares issued as fully paid), the full amount had been called, while upon the remaining 1,466 preference and 1,252 ordinary shares a call of £3 per share had been made, resulting in the payment of £198,834.

REGENT PORTABLE ELECTRIC LAMP AND LIGHTING COMPANY (LIMITED).—As the above-named Company had filed no returns since its incorporation, it has been dissolved by notice in the *London Gazette*, dated June 21, 1892. The Company was registered on August 27, 1886, with a capital of £85,000, in £5 shares, to acquire the exclusive licence for manufacturing and selling the Regent Primary Battery, in accordance with the said licence, for all purposes in connection with the electric lighting in Great Britain and Ireland.

WATER PRIMARY BATTERY COMPANY (LIMITED).—In spite of repeated notices the above-named Company has not complied with the regulations, and a notice has just been filed that the Company has been dissolved. The Company was registered on December 23, 1886, with a capital of £100,000, in £5 shares, to enter into an agreement with Paul R. de F. D'Humy for the acquisition of certain patents and to carry on the business of manufacturers of and dealers in machines, chemicals, and appliances for the production, storage, and transmission of electricity. On August 6, 1887, 3,000 shares had been taken up, of which all had been issued as fully paid, and no return has been filed since that date.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 3rd were £763, as against £719 for the corresponding period of last year, being an increase of £44. The total receipts to date, from January 1st last amount to £21,210, against £19,917 in the corresponding period of 1891, being an increase of £1,293.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of June were £3,400, as compared with £3,509 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the month of June amounted to £1,966, as compared with £1,882 in the corresponding period of last year, an increase of £84.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the month of June amounted to £52,173, against £52,341 in the corresponding period of 1891, being a decrease of £168.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of June amounted to £41,738, and to £39,749 in the corresponding period of last year, an increase of £1,989.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—Subject to audit, the shareholders will be recommended at the forthcoming general meeting to declare a dividend on the "A" shares of the Company, of 5s. 8¾d. per share on the 89,261 ordinary shares, £3 paid; of 9s. 6¼d. per share on the 5,000 £5 fully-paid shares allotted to the Edison Electric Light Company (Limited); and of 8s. 10⅞d. per share on the 12,139 £5 fully-paid shares allotted to the Swan United Electric Light Company (Limited), free of income tax, being, with the interim dividend paid on February 22, 1892, 7 per cent. in respect of the year ended June 30, 1892, 7 per cent. in payment of arrears of cumulative preferential dividend for the year ended June 30, 1887, and of 4 per cent. in respect of the year ended June 30, 1888; all to be distributed in accordance with the provisions of Clause 87 of the "Articles of Association."

ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to allow the additional shares of this Company to be quoted in the official list.

ENGINEERING EXCHANGE (LIMITED).—A prospectus of this undertaking has been issued, which is incorporated with a capital of £10,000 in £10 shares, payable: £1 on application, £1 on allotment, £1 one month after allotment, and the balance at the discretion of the Directors. In the twenty names forming the committee of the Exchange are included the following: Mr. Charles Churchill, Mr. J. Alfred Fisher, Mr. F. H. Nalder, Mr. James Paxman, Mr. F. L. Rawson, and Mr. A. H. Tyler. The registered offices ar situate at 33, Old Broad-street, E.C., and the exchange rooms at Billiter House, 22, Billiter-street, E.C. The secretary is Mr. A. T. Salisbury-Jones.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for June, 1892, amounted to £24,000; and from January 1st to June 30th to £128,800. In the corresponding months of 1891 and 1890 the amounts were £141,400 and £130,400 respectively.

HOBART TRAMWAY COMPANY (LIMITED).—The first ordinary general meeting of the shareholders of this Company was held at the offices on Thursday, last week, under the presidency of Sir Edward Braddon, K.C.M.G. The Chairman said it had been decided to use overhead electrical power, which they believed to be not only the best but the cheapest; and terms of a very favourable character had been made with the eminent firm of Messrs. Siemens Bros. and Co. (Limited), to whom the work of equipment and carrying on the line during the first twelve months had been entrusted. He defended the Directors' estimate of traffic and reminded the shareholders that the Company, besides the revenue they will acquire by passenger traffic, will also earn money from the carriage of goods and parcels; and further, that the electrical plant to be put up may very probably prove revenue earning, as the Company will be in a position to supply electricity for public or private service to the citizens of Hobart.

INDIA-RUBBER ESTATES COMPANY (LIMITED) (IN LIQUIDATION).—The creditors of this Company met on Thursday, last week, at Carey-street, Lincoln's-Inn-fields, before Mr. Warley, assistant receiver, to consider the present position of affairs. In the course of the meeting, the Chairman announced that a total sum of £4,620 had been realised from the assets up to the present time. The Official Receiver had a sum of £595 in hand, and anticipated being able to recover a further sum of about £200. A dividend of 15s. in the pound had already been paid to the creditors, and a further dividend of 2s. 6d. or 3s. in the pound would be declared. The concession was in the hands of the Liberian Concessions Company, who had a claim of £631 15s. against the India-Rubber Estates Company; but negotiations were pending under which it was anticipated that the Liberian Concession Company would, in exchange for the Company's interests in the concession, withdraw their claim, pay a sum to the Official Receiver for the benefit of the creditors, and allot 5,000 shares in their own company to the shareholders in exchange for the shares in the India-Rubber Estates Company now held by such shareholders. The meeting was adjourned for a week

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to enable the negotiations with the Liberian Concessions Company (Limited, to be carried through with a view to an amicable settlement.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—Notice is given in our advertisement columns that the transfer books of this Company will be closed from the 4th inst. to the 12th inst., both days inclusive, preparatory to the payment of an ad interim dividend of 12s. per share to all shareholders on the register on the 4th inst.

MANITOBA ELECTRIC AND GAS LIGHT COMPANY.—Messrs. Robert A. MacLean and Co. will, on and after to-day, pay the half-year's interest due on that date on the Six per Cent. First Mortgage Debentures of this Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the fortnight ended June 30, 1892, amounted to £2,204, as compared with £2,265 in the corresponding period of last year, a decrease of £61.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 1, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,701.

WOODHOUSE AND RAWSON UNITED (LIMITED).—The Stock Exchange Committee have been applied to to appoint a special settling day in the ordinary and preference shares of this Company.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 22.	Price Wednesday, June 29.	Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending June 29.	
						£ s. d.		Highest.	Lowest.
			TELEGRAPHS						
£1,300,980	Stock	12/6	Anglo-American	48 49	48 49	5 8 1	Jan., Apr., July, Oct.	..	..
£2,849,510	Stock	25/0	Do. Preferred	88 89	88 89	5 18 0	" "	..	..
£2,849,510	Stock	5/0	Do. Deferred	10⅜ 11⅛	10⅜ 11⅛	..	" "	..	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures .... xd	101 104	99 103	3 17 8	January and July ..	101⅜	..
130,000	£10	3/0	Brazilian Submarine ..... xd	10¼ 10¾	10¼ 10¾	6 10 3	Mar., June, Oct., Dec.	10 7/16	..
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	103⅜	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)..xd	105 109	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1⅓	Commercial Cable Capital Stock	155 160	155 160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3¼ 3⅜	3¼ 3⅜	4 16 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅜ 11⅝	11⅜ 11⅝	6 0 8	Jan., Apr., July, Oct.	11⅛	11 3/16
400,000	10	2/6	Eastern	14⅜ 15	14⅜ 15	4 6 8	" "	15⅛	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	15⅞ 15⅝	15⅛ 15⅝	3 16 2	" "	15⅝	15 3/16
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.....	108 111	108 111	3 12 1	May and November	110⅛	110
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15 15¼	15 15¼	4 11 10	Jan., Apr., July, Oct.	15⅜	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 ..xd	104 107	101 104	4 16 2	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,190(xd	103 106	100 103	4 17 1	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)....	102 105	102 105	3 16 2	February & August	..	..
180,227	10	2/6	Globe Telegraph and Trust.....	10⅛ 10⅜	10⅛ 10⅜	5 1 2	Jan., Apr., July, Oct.	10⅜	10 3/16
180,042	10	6%	Do. 6 per Cent. Preference	15⅛ 15⅜	15⅛ 15⅜	3 18 1	" "	15⅜	15⅛
150,000	10	5,0	Great Northern ..... xd	18¾ 19¼	18½ 19	4 9 6	Jan., April, and July	18 1/16	18 3/16
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	40 42	40 42	5 19 1	May and November	41½	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
10,502	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October...	..	..
3,381	£100 Cert.	£1⅓	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	116½	..
15,609	10	3/0	West African Telegraph	7 8	6 8	5 0 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	3½ 4½	3½ 4½	5 11 1	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902 ..... xd	105 109	101 105	7 12 5	June and December	..	..
88,321	10	6d.	West India and Panama	1¼ 1½	1¼ 1½	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference.....	9½ 10	9½ 10	6 0 0	May and November	9⅝	9½
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
67,007	15	6/0	Western and Brazilian	8¾ 9¼	8¾ 9¼	6 9 7	" "	8⅛	8¾
30,364	7½	1/8	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 7	" "	..	..
30,364	7½	4/6	Do. 5 per Cent. Deferred	2¾ 3¼	2¾ 3¼	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105 108	105 108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910..	105 108	105 108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
124,850	14/0	1¼d.	Consolidated Telephone Const. & Maintenance ..	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	1/16 1/8	1/16 1/8	6 5 0	Yearly	..	..
438,984	5	2/6	National	4⅛ 5⅛	4⅛ 5⅛	5 17 1	June and December	5 1/16	5
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½ 13⅝	13⅝ 14½	4 4 3	" "	13⅝	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12¾ 13¼	12¾ 13¼	4 10 7	" "	13⅛	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.) ..xd	109 111	108 110	4 1 10	January and July ..	109½	108
58,000	5	1/0	United River Plate	1½ 2⅛	1½ 2⅛	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock..... xd	85 95	85 95	5 5 3	—	—	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£8 paid)	10½ 10⅝	10 10½	..	—	10½	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	..	..
8,332	£5	..	House to House Electric	2½ 3½	2½ 3½	..	—	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5⅜ 6	5⅜ 6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5⅜ 6	5⅜ 6	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16	3 7/16 3 9/16	..	March	..	..
10,030	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	⅜ 1⅜	⅜ 1⅜	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7⅛	6⅜ 7	..	..	6 9/16	..
6,318	10	..	Notting Hill Electric Lighting (fully paid).....	4 5	4 5	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8⅛ 8⅜	8 8⅛	—	..	8⅜	..
7,900	£5	7%	Do. 7% Preference	7⅜ 8⅛	7⅜ 8⅛	..	..	..	..
42,853	5	..	Westminster Electric Supply (fully paid)	6⅛ 6⅜	6⅛ 6⅜	..	..	6⅜	6⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/0	Brush Electrical Engineering.....	2 7/8 3⅛	2 7/8 3⅛	..	..	3 1/16	2 15/16
69,996	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2 1/16	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5½ 6	5 16 8	January and July ..	..	..
17,139	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅛ 5⅜	5 5⅛	..	—	5⅛	4 7/8
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜ 2¾	2⅜ 2⅝	—	—	2¼	2⅛
20,000	5	..	Fowler-Waring Cables (fully paid).....	2 3	2 3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha &c., Works	20 21	20½ 21½	5 16 3	February & August	21⅛	20⅝
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	6½ 7½	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛ ⅜	⅛ ⅜	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3¼ 3⅜	3¼ 3⅜	10 5 7	May and November	3⅛	3⅛
36,250	12	36/0	Telegraph Construction and Maintenance	45 47	45 47	5 2 1	March and July.....	45½	45
150,000	100	5%	Do. 5 per Cent. Bonds, red.1894 ..... xd	103 106	103 106	4 14 4	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)..	⅛ ⅜	⅛ ⅜	..	..	..	..
—	£5	8%	Do. Preference (fully paid).....	2½ 3	2½ 3	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,550	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
50,000	£10	—	City and South London Railway	2½ 3½	2½ 3½	—	..	..	..

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THE ELECTRICIAN:

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NOTES.

Litigation about glow-lamp patents has ceased to interest most of our readers, and we need not therefore give much attention to the recent decision in the American Courts. The United States Electric Lighting Company proceeded against the Edison Lamp Company for infringement of Weston's "flashing" patent. It was proved that the exhibition of a number of lamps by Sawyer and Man containing flashed carbons between March, 1878, and May, 1879, was a "practical and public use," and the validity of their patent was therefore upheld. This was some time before Edison had turned his attention to carbon. The English patent for flashing, known as the "Cheeseborough" patent, was for this invention, Cheeseborough being the name of the patent agent employed by Sawyer and Man. Because the Edison and Swan Company fought over this patent in 1888, many people thought, and still think, that "flashing" was invented by Edison. A few others still believe that Cheeseborough was a forgotten pioneer. The "flashing" patent expires on November 28 of the present year. The Edison carbon filament patent expires on November 10 next year.

We have already recorded the result of the action of the Electrical Trades Section of the London Chamber of Commerce with regard to the overhead wire rules of the London County Council. After all the trouble about the Board of Trade rules which touch on a closely allied matter, the assistance of that body was very welcome; and Major Flood Page's assurance that the Board of Trade officials are most willing to try and alter anything that is really restrictive to trade is very satisfactory. It is, of course, easier to contemplate alterations in somebody else's rules than in one's own; but we look forward to the time when, the interference of the London County Council having become unbearable, all these matters will be efficiently carried out by a competent and well-equipped Electrical Department of the Board of Trade.

The application for space in the Electrical Section of the Chicago Exhibition by English firms is not surprisingly small, but the representation of English electrical engineering is ridiculous. Only 5,000 square feet have been taken up out of the 20,000 which have been allotted. More than one-fifth of this will be occupied by Elwell-Parker machinery, while the only other specimens of dynamo machinery which are promised are those of Parsons and Ferranti. No better types could perhaps be selected to attract attention, on account of their strong originality. The makers of the biggest dynamo and of the fastest-running one ought not to be absent from such a show; and we hope that they will not be disappointed in their venture. One other substantial firm is exhibiting, and Mr. Binswanger knows well what he is doing; but after these, a deluge of electrical ventilators and homacoustic speaking-tubes, and the like. After reading Mr. Preece's list, which will be found in another column, we are almost inclined to think that there may be something in his idea of a syndicate and a comprehensive show to cover say another 5,000 feet with some really first-rate selections; but it is not improbable that many dynamo makers agree with the steam-engine makers as to the policy of exhibiting at all.

At the last meeting of the Commission of Sewers the engineer asked for authority to get a new plan of the City. The present one was prepared about twenty years ago, and the copies are now exhausted. It was suggested some years since that whenever electric mains were laid, an accurate plan of their route should be made. Supply companies use the Ordnance maps as a rule, but the position of the conductors can be only approximately given on them, on account of their small scale and the numerous alterations which have been made since the date of the survey. The London County Council has missed a grand opportunity for doing something very useful. It might have provided a staff of surveyors to note the position of all pipes that were exposed whenever the streets were opened, and of all wires and pipes that have been laid, and conduits that have been constructed. We have often stopped to look into excavations during the laying of electric mains, and have marvelled at the network of gas and water pipes; but we should be glad to know if sketches are regularly made of the bowels of the streets either by the contractors or by the local authorities.

The discussion of the dimensions of physical quantities can, perhaps, only be interesting from a purely scientific point of view. Its value in theoretical work has, however, been frequently shown, notably, for instance, in connection with the electromagnetic theory of light; and we cannot share the hopeless view, expressed in another column, that dimensions are useless, and should be suppressed altogether. The article on this subject, which we publish to-day, is, nevertheless, interesting, because it points out many of the difficulties which

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must be surmounted before a clear and complete interpretation of dimensional equations can be given. Our correspondent, "W. M. M.," thinks that this is practically impossible, since, if otherwise, it is remarkable that it has not yet been done. He also advances the disputable opinion that "these physical equations" are to be regarded as a "hindrance in education, since they are one more step in the direction of making our symbols do our thinking for us; and of this there is already too much in mathematics." Whether this is or is not an argument against the use of these equations for educational purposes, it is an admission of their usefulness in other directions.

The more we can utilise symbols as thinking machines the better. The processes used in any mathematical research are analogous with those of a slide rule. Data are supplied to start with, certain recognised operations are gone through, and a result is arrived at, which is a necessary consequence of the data given, but which would have been difficult, if not impossible, to think out. In the same way the study of dimensional equations sometimes yields results which could not have been arrived at so readily by other methods.

The very interesting correspondence which has been elicited by our remarks on carbon brushes for dynamos has touched only on the practical side of the question, but even here there are some discrepancies. Mr. Sayers, using brush-holders intended for copper brushes, can only give about 0·624 square inch for 60 amperes, say, 100 amperes per square inch, and is sometimes compelled to use 200 amperes per square inch. Mr. Dallas gives figures which work out to 75 amperes per square inch, Mr. Housman recommends no more than 40 or 50 amperes, and Mr. N. G. Thompson only 30 amperes. The theory of the carbon brush we leave for a future occasion.

In our "Legal Intelligence" columns we publish the summaries of arguments which were handed in by both plaintiff and defendant in the Lane Fox appeal. It is very unusual, after full *viva-voce* arguments, to allow any such document to be provided; but it was done at the suggestion of Lord Justice Lopes. The *Glasgow Herald* notices this as an interesting precedent, and says that this concession, which involves a return to an early practice in the history of English pleading, is not only a great assistance to the Bench, but an advantage to litigants, who are thus enabled to avoid the risk of errors creeping into the Judges' notes, and it is believed that in similar cases it will be granted to suitors as a matter of course.

The nature of the demand for domestic electric lighting may be judged from the meters in use. We learn that, during last year, Messrs. Ferranti and Co. found that 25-ampere meters were chiefly asked for; but now the 15-ampere size is most popular. The demand for 5-ampere meters is still increasing, which shows that small houses, fitted with only 14 or 15 lamps, are taking up the supply. This increase of small customers is very satisfactory, and it is probable that they will use their lamps with greater economy than is general in large establishments.

We understand that the legalisation of the ampere, volt, and ohm has been deferred, in order that another attempt may be made to arrive at an international arrangement With this in view, Prof. von Helmholtz is expected to attend the meeting of the British Association, and it is hoped that Profs. Mascart and Rowland will also be present.

Electric Tramway in Normandy.—The Chamber of Commerce of Honfleur have been asked to consider the construction of an electrical tramway between Honfleur and Trouville.

Chiswick.—The Chiswick Local Board give notice of their intention to transfer to Messrs. Bourne and Grant for a period of 21 years the powers granted to them under their Electric Lighting Order.

"Sounder" v. "Morse."—In the new chief office of the Posts and Telegraphs in Brussels telegraphic receivers of the "Sounder" type are being installed in place of the "Morse" type, which have been in use during the last four years.

Cable Interruptions.—

Mossamedes, Cape Town	June 26, 1892.
Sierra Leone, Accra	July 14, 1892.

By these interruptions all telegraphic communication with the West Coast of Africa between Accra and Mossamedes is cut off.

Enamel Insulation.—Resistances for motors, &c., are being made in Chicago with wire buried in enamel, making a fireproof and compact arrangement. They will probably take longer to warm up, and will not be able to get rid of their heat as readily as wire coils.

Barnsley.—After considering two electric lighting schemes, the Lighting Committee of the Barnsley Town Council have reported in favour of a continuous-current scheme, and recommend that application be made to the Local Government Board for sanction to borrow £18,382.

Copper.—In future, says the *Financial Times*, the Anaconda Company, instead of shipping its matte to Europe, will have it refined at Baltimore. As one practical effect of this change, the Americans will send us more fine copper than ever, and have proportionately greater control over our market.

The Cable Fleet.—Owing to the death of Captain Fawcus, of the Eastern Extension, Australasian and China Telegraph Company's service, Captain Madge has been transferred to the ss. "Sherard Osborn," from the ss. "Recorder," to which latter vessel Captain Brereton, first officer of the "Sherard Osborn," has been appointed.

Bruce's Signalling Balloon.—Experiments were made last week, at the Stamford Bridge Grounds, with a modified and improved sigualling balloon. The balloon, which is 18ft. in diameter, is made of varnished cambric. Glow-lamps are used either inside or outside, current being supplied by a twin wire. The improvements consist in reduction of weight in the fittings as well as in the cable.

Breslau.—We learn that the work of construction of the electric tramway in Breslau will be proceeded with very soon, and the line is to come into operation next summer. It is proposed to have four lines, with through car communication. The total length of rails will be 28 kilometres—a length to which no existing Continental electric tramway has attained as yet. The line will be worked on the overhead conductor system.

Bradford Tramways.—The Electric Lighting Committee of the Bradford Corporation have offered to supply the Tramways Committee with power for the Wakefield-road trams at 2½d. per unit, on condition that at least 120,000 units are used per year. This will give the Tram Committee a working basis upon which to advertise for tenders for the new line. The

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Committee are said to have under consideration the advisability of adopting the use of cheap gas power instead of steam.

Gas Mains and Steam Rollers.—From some correspondence which has appeared in a recent number of the *Gas World* we learn that considerable damage has been done to the gas mains in the streets of Cork by a steam roller. Several manufacturing and business firms were without a supply of gas, and one firm had four gas engines and 70 men standing idle. Fortunately a water pipe was also fractured, and the water escaped into the gas pipes, thus preventing, we are told, the consequences from being more serious.

Pacific Cable Survey.—The United States survey steamer "Thetis" arrived at Honolulu on May 20th from Hilo, where she ended the survey for the proposed cable between San Francisco and the Hawaiian Islands. The course to Hilo comprised 2,060 miles as surveyed by the "Thetis," with 300 soundings, against the survey of the "Albatross" of 2,150 miles, and 250 soundings. The soundings were made at intervals of ten, two, and sometimes one mile apart. The deepest was 3,228 fathoms, about 245 miles north-east of Hilo, and the shoalest was 976 fathoms, at a point about 350 miles from Point Conception.

Charlottenburg.—Messrs. Siemens and Halske have, according to some of the Berlin papers, made application for a concession for the construction of an electric tramway from the Spandauer Bock on the Spandauer Chaussee as far as the municipal boundary of Charlottenburg. The concession of the present horse tramway which works the traffic in the above districts expires on the 1st July, 1895. As the existing tramway, which unites the southern portion of Berlin with Charlottenburg, hardly meets the requirements of the day, Messrs. Siemens and Halske propose to extend the electric road from the Charlottenburg boundary on to Berlin.

British Association.—The sixty-second annual meeting of the British Association will commence on Wednesday, August 3, 1892, under the presidency of Sir Archibald Geikie. The general secretaries are Captain Sir Douglas Galton and Mr. A. G. Vernon Harcourt. The assistant general secretary is G. Griffith, Esq., and the local secretaries for the meeting are: Professor G. F. Armstrong, Messrs. John Harrison and F. Grant Ogilvie. Local treasurer for the meeting at Edinburgh, Adam Gillies Smith, Esq. The presidents of sections are:—Section A., Mathematical and Physical Science, Prof. Arthur Schuster; B., Chemistry and Mineralogy, Prof. Herbert McLeod; C., Geology, Prof. Charles Lapworth; D., Biology, Prof. W. Rutherford; E., Geography, Prof. James Geikie; F., Economic Science and Statistics, the Hon. Sir C. W. Fremantle; G., Mechanical Science, Prof. W. C. Unwin; H., Anthropology, Prof. Alexander Macalister.

Graphite and Graphitite.—Graphite plays an important part in the manufacture of arc-light carbons, and has in the process to be first of all finely powdered. According to some researches of W. Luzi (*Deutsch. Chem. Gesellschaft*, Vol. XXIV.), certain kinds of graphite, which he proposes to call *graphitite*, may be very easily reduced to powder by chemical means. It has been known for some time that graphite boiled in certain reagents, and then washed and dried, swelled in a most extraordinary fashion when baked. These reagents were concentrated sulphuric acid and a mixture of concentrated sulphuric and nitric acid. W. Luzi finds that fuming nitric acid is also a reagent. The graphite which exhibits this peculiarity of swelling comes from the following sources:—Ticonderoga, Pfafferreuth, Ceylon, Buckingham (Canada), Argenteuil (Canada), Massachusetts, Amity (N.Y.), Greenville (Ont.). The so-called graphitite comes from Passa (Siberia), New Mexico, Burkhardtswald (Saxony), Idar, Fichuelgebirge, Diedelkopf (Tyrol), Levigliani (Italy).

Exports of Telegraphic Apparatus.—The Board of Trade returns for June show a very small export of telegraphic wire and of apparatus connected therewith, the total value of our exports for the first half of the current year falling below the figures for the corresponding half years of 1890 and 1891. In April last our exports were valued at over £400,0 0, but this amount has not been sufficient to offset the falling-off in the other months of the half-year. The following is a monthly statement of exports in comparison with the corresponding periods of the two previous years:—

	1890. £	1891. £	1892. £
January	71,686	238,223	46,246
February	201,594	22,306	31,006
March	51,390	392,552	18,827
April	187,733	59,226	447,883
May	57,081	51.238	107,696
June	152,228	220,985	24,177
	721,712	984,530	675,835

Iron for Electrical Purposes.—Many text-books say a good deal about the permeability of iron. This is a matter of comparatively small importance; what we really want to know, says *Industries*, relates to magnetic hysteresis. The universal instruction at present is, "Buy soft Swedish charcoal iron." This is good, but not cheap. Makers want an iron which is cheap and which is always good and can be depended upon. It should have high specific resistance. This is a point which, we believe, is always neglected. It may be incompatible with small hysteresis. If not, however, it admits of the use of thicker iron, and this is cheaper and more easy to work. Another point, generally overlooked, is that the iron must not harden easily. Whether there are differences in this or not we do not know. A very little rough handling in the works will double the hysteresis loss in an armature. If a particular grade of iron has slightly greater hysteresis than another, but will stand straining without hardening, it may be much better in practice than a quality which is better when perfectly annealed.

The Central Stations of Europe.—The following statistics are based on a table published in the *Bulletin de la Société Belge d'Electriciens*. According to this authority there are 21 central stations in Europe from which distribution on the plain two-wire system takes place; the two largest being those at Lyons (16,400 8-c.p. lamps) and at Bilbao (8,000). There are no less than 36 three-wire central stations from which the equivalent of more than 600,000 8-c.p. lamps can be supplied. There are only three examples of the five-wire system, namely in Paris (Place Clichy), Königsberg and Trient, but their lamp capacity amounts to close on 70,000. Some 23 central stations employ accumulators in parallel with the dynamos, and five have adopted the accumulator sub-station system. Four stations employ continuous-current transformers, and 55 employ alternate-current transformers, the latter having a total 8-c.p. lamp capacity of something like three quarters of a million. A single station, that at Heilbronn, is worked on the "rotary current" system. Some 39 stations, mostly small ones, are not included in any of the above categories.

Water Level Indicator.—Many clumsy and a few ingenious electrical devices have been tried for measuring the depth of water at a distance. Prof. F. J. Smith describes the following very interesting and apparently practical method in yesterday's *Nature*:—

"About two years ago I wished to know from time to time the rate at which a river was rising after a fall of rain. The river was at a considerable distance from the spot where its height was to be known. By means of the combination of two organ pipes, and a telephonic circuit, described in the following lines, I have been able to make the required measurement within rather close limits. At the river station, an organ pipe was fixed vertically in an inverted position, so that the water in the river acted as a stopper to the pipe, and the rise or fall of the water determined the note it gave, when blown by a small bellows driven by a very small water wheel. A microphone was attached to the upper end of the organ pipe; this was in circuit with a wire leading to a town station at some distance; at the town station there was an exactly similar organ pipe, which could be lowered into a vessel full of water while it was sounding. By means of the telephone the note given by the pipe at the river was clearly heard at the town station; then the organ pipe at this station was lowered or raised by hand until it gave the same note. The lengths of the organ pipes under water at the two stations were then equal, so that the height of the water in the distant river was known. The determination can be made in less than a minute by any one who can recognise the agreement of two similar notes. The arrangement when first tested was so placed that the height of water at two places near together might be easily compared. I found that a lad with an average ear for musical sounds was able to get the two heights to agree within one-eighth of an inch of each other, while a person with an educated ear adjusted the instrument immediately to almost exact agreement. The total height to be measured was 17 inches.

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A difference of temperature at the two stations would make a small difference in the observed heights. For example, taking a note caused by 250 vibrations per second, a difference of 10°C. between the temperatures of the two stations (one not likely to occur) would make a difference of about 0·02 foot in the height, a quantity of no moment in such a class of measurements. The organ pipes were of square section, and made of metal to resist the action of the water."

The Utilisation of Central Station Exhaust Steam.—The American central-station engineer in quest for a dividend has lately lighted upon a source of profit which, unfortunately, is not equally available to his English *confrère*, namely, the utilisation of the exhaust for steam-heating purposes. At Springfield, Ill., the exhausts of the engines are connected to the mains of the steam-heating plant, which are 8 inches in diameter and which shortly after leaving the station branch into smaller mains, 6 inches in diameter. This exhaust steam is being furnished for heating to about 16 business blocks, and not the least difficulty has been found in securing in the immediate vicinity of the station all the business that can possibly be taken care of. Ordinary radiators are employed, and something over 2,000,000 cubic feet of air space is now being heated, and this will be increased to over 3,000,000. The amount of power of exhaust steam at present in service at a pressure of about 5lbs. is 200 horse-power. Contracts are now based upon a charge of 20 cents per foot of direct radiation per year, or 25 cents on indirect radiation. The use of this system, while yielding a most generous profit to the station, is also cheaper for the consumer; and from the fact of steam being on day and night it has been demonstrated that 25 per cent. less heating surface is required than where the heating is done by boilers in the buildings; in many cases this percentage of radiating surface has been taken out on account of the heat being greater than required. An average estimate for the amount of heating surface required is one square foot of radiation to 50 cubic feet of air. At the station an automatic device is provided to prevent the pressure exceeding 5lbs., and the 5lbs. back pressure on the engines is compensated for by an additional 5lbs. pressure on the boilers. The additional amount of fuel required during the time of heating does not exceed 5 per cent.

Oxidation of Nitrogen by Electric Sparks.—A Paper upon the oxidation of nitrogen by means of electric sparks is contributed, by Dr. V. Lepel, to the current number of the *Annalen der Physik und Chemie*. It is well known that small quantities of nitric and nitrous acids and their ammonium salts are produced during the passage of high-tension electrical discharges through moist air. Dr. V. Lepel's experiments have been conducted with the view of obtaining more precise information concerning the nature of the chemical reactions which occur, and the experimental conditions most favourable for increasing the amount of combination. The first action of the spark discharge appears to be the production of nitric oxide, which is immediately converted by the oxygen present into nitrogen peroxide. The latter then reacts with the aqueous vapour present, forming nitric acid and liberating nitric oxide in accordance with the well-known equation $3NO_2 + H_2O = 2HNO_3 + NO$. It has been found, however, that the passage of sparks through the gaseous oxides of nitrogen first formed, results in their decomposition again into their elementary constituents. Hence it is that, in a closed space, a limit is soon reached beyond which there is no further increase in the amount of nitric acid. For this reason the yield of nitric acid has hitherto been very small. Dr. V. Lepel has made experiments, therefore, with a slowly moving atmosphere, and under different conditions of pressure, and with various types of spark discharge, with the result that he has already increased the amount of combination to 10 per cent. of the total amount of air employed. Of particular interest are his remarks concerning the probable effect of the high-voltage discharges of which we have lately heard so much. He considers it not improbable that by their aid a new mode of producing nitric acid from the atmospheric gases on the large scale may be introduced, rendering us altogether independent of the natural nitrates as a source of nitric acid.

The Periyar Irrigation Project in Madras.—The Government of Madras, says Prof. Alfred Chatterton in the *Indian Engineer*, are engaged in diverting the water of the Periyar river, which rises in the Western Ghauts and flows into the Arabian Sea near Cochin, so as to make it available for irrigation purposes near the town of Madura. The works, which have been designed by and are being carried out under the superintendence of Colonel Pennycuick, R.E., consist in the construction of a masonry dam 155 feet high, whereby the waters of the river will be dammed back to form a lake having a superficial area of over 10 square miles, and containing at the level of the escapes 13,299 million cubic feet of water. The water thus stored will be taken through the watershed ridge by a cutting and tunnel. The quantity of water stored which it will be possible to draw off amounts to 6,815 million cubic feet, but as the water-shed is situated in a region where the rainfall is at least 100 inches per annum, and as the area amounts to about 300 square miles, and as the rainfall is distributed over more than eight months of the year from April to December, it will be possible to draw off from the lake a quantity of water equal to 1,500 cubic feet per second from the middle of April to the middle of December; and as at the end of that time the lake will still be full, it will contain enough water to deliver 750 cubic feet per second for three months, and the drainage from the occasional showers which fall in the earlier months of the year will be more than sufficient to give the extra month's supply which is required. The tunnel through the ridge will be about a mile long, and will deliver the water on the eastern side of the Ghauts at an elevation of about 2,850 feet above the sea. The hills rise very abruptly on this side, so that in about a mile the water will fall some 1,300 feet. It is this fall of 1,300 feet immediately after the exit of the water from the tunnel that it is proposed to utilise for power purposes. It is situated near Kuruvanuth, a small village at the head of the Cumbum valley, some 70 miles from Ammanayakanur, the nearest railway station on the South Indian Railway, which is 320 miles from Madras.

Telephone Enterprise in Belgium.—Mr. Conyngham Greene, of the British Legation in Brussels, has lately written a report on the history and progress of telephone enterprise in Belgium, from which it appears that up to 1883 the telephone service in that country was in the hands of private companies, and the uncertain character of the concessions granted by the State checked the free expansion of private enterprise. Between 1880 and 1883 three separate telephone systems were in operation in Brussels, but, owing to competition and the refusal of the companies which worked the lines to grant mutual subscriptions over the lines of their rivals, no great success was obtained by any of them. In 1883 the State Department of Posts and Telegraphs took the initiative in organising and developing the telephone system of the country. A law was then passed authorising the Government to undertake themselves, or to concede on fixed conditions to others, the establishment and development of telephone lines. In a few months the Bell Telephone Company bought up the two rival companies of Brussels and secured a concession not only for the capital itself, but also for Ghent, Antwerp, Verviers, and Charleroi. The Company started with a paid-up capital of £105,400, of which more than two-thirds was devoted to buying up the rival plant and apparatus and replacing that which was worn out and inefficient. The existing wires were replaced by phosphor-bronze wires on the Montefiore system. Owing to the superior capability of this wire for bearing a strain, it was found possible to diminish the number of supports, and thus to get rid of much useless material. Moreover, the expense of repairing the wires was materially reduced, as breakages were of very rare occurrence, and the interruption of the service proportionally unusual. By way of dividend the Company distributed in 1889 among its shareholders £10,750, and £15,181 in the following year, while the number of subscribers rose from 4,051 on December 31, 1888, to 4,726 in 1892. The State has also laid and worked lines of its own to the less important centres which were somewhat neglected by the companies. A system of receiving and transmitting telegrams by telephone to subscribers has been introduced and has proved a great success. The repurchase of all the telephone concessions by the State will probably take effect from January 1st next, when a further large extension of the telephone system will take place. It appears, however, that in regard to Press messages between Paris and Brussels the telephone has wholly supplanted the telegraph.

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ELECTROMAGNETIC THEORY.—XXXII.

BY OLIVER HEAVISIDE.

(*Continued from page 189.*)

§ 148. As we see from the preceding that the propagation of electromagnetic disturbances through a non-conductor can be imitated in an incompressible solid, possessing the usual distortional rigidity, let us next introduce electric conductivity on the one hand, and examine what changes are needed in the analogies of §§ 146, 147 to keep them working, if it be possible. Since there is waste of energy associated with the conduction current, it is clear that some sort of frictional forces requires to be introduced into the elastic solid.

First try distortional friction. The equation of motion of an incompressible viscous solid is

$$\mathbf{f}_1 = [\rho p^2 - (n_0 + n_1 p)\nabla^2]\,\mathbf{G}, \quad . \quad . \quad . \quad (329)$$

where $\mathbf{f}_1$ is the impressed force per unit volume, $\mathbf{G}$ the displacement, ρ the density, n_0 the rigidity, and n_1 the associated frictionality. Also, p stands for d/dt, for practical convenience in the operations, whether direct or inverse. Thus, $p^{-1}\mathbf{q}$ or $\mathbf{q}/p$ means the time-integral of $\mathbf{q}$, which would in the ordinary notation of the integral calculus be expressed by $\int_0^t \mathbf{q}\,dt$, a notation which is not convenient for manipulative purposes in investigations of this class. We may derive (329) from (324) by changing n to $n_0 + n_1 p$; or by (306), (313).

Now the circuital equations of $\mathbf{E}$ and $\mathbf{H}$ in a conducting dielectric (homogeneous, isotropic, stationary), are

$$\text{curl}\,(\mathbf{H} - \mathbf{h}) = (k + cp)\,\mathbf{E}, \qquad \text{curl}\,(\mathbf{e} - \mathbf{E}) = \mu p \mathbf{H}, \quad . \quad (330)$$

comparing which with (323) we see that the effect of introducing conductivity is to change cp to $k + cp$, so that the equation of $\mathbf{H}$ is got by making this change in (325), giving

$$\mathbf{f} = \left(\mu p - \frac{\nabla^2}{k + cp}\right)\mathbf{H} = \left(\mu p^2 - \frac{p\nabla^2}{k + cp}\right)\mathbf{Z}, \quad . \quad . \quad (331)$$

where $\mathbf{Z} = \mathbf{H}/p$. But on comparing this equation with (329), we see that the viscosity in the one case and the conductivity in the other enter into the equations in different ways. We can only produce a proper correspondence when the coefficients of ∇^2 are equal; or, in another form, when the operators $p(k + cp)^{-1}$ and $(n_0 + n_1 p)$ are equivalent in effect. This is not generally possible. But there are two extreme cases of agreement. One we know already, viz., when there is no conductivity and no viscosity, as in § 146. The other is when there is no permittivity and no rigidity, which is sufficiently important to be separately considered.

§ 149. This is the extreme case of a pure conductor, or a conductor which cannot support elastic displacement. It dissipates energy, but does not store it electrically; though, on the other hand, its magnetic storage capacity is retained. It is compared with an incompressible viscous solid with the rigidity abolished; that is to say, with an incompressible viscous liquid. Put $c = 0$ in (331), and we have the equation

$$\mathbf{f} = (\mu p - k^{-1}\nabla^2)\mathbf{H}; \quad . \quad . \quad . \quad . \quad (332)$$

and putting $n_0 = 0$ in (329), with $\mathbf{q}$ the velocity substituted for $p\mathbf{G}$, gives us the equation

$$\mathbf{f}_1 = (\rho p - n_1\nabla^2)\mathbf{q} \quad . \quad . \quad . \quad . \quad . \quad (333)$$

in the liquid. These admit of immediate comparison. Observe, however, the curious fact that whereas in § 146 the permittivity was the reciprocal of the rigidity, so that the vanishing of one means the infinitude of the other, yet now both the permittivity and the rigidity vanish together, as if they were equivalent. This emphasises the incompatibility of (329), (331). Our present analogy must stand by itself, all idea of permittivity and rigidity being thrown away.

We compare magnetic force $\mathbf{H}$ in a pure conductor with the velocity $\mathbf{q}$ in a viscous liquid; the inductivity μ with the density of the liquid, so that the magnetic energy and the kinetic energy are compared, and the current is twice the spin. Also the source $\mathbf{f} = \text{curl}\,\mathbf{e}$ in the case of the conductor is compared with circuital impressed force in the liquid. So far is the same as in § 146. But now, in addition, we have the electric resistivity k^{-1} represented by the liquid viscosity. We conclude that the disturbances $\mathbf{q}$ generated by $\mathbf{f}_1$ in the liquid are similar to the disturbances $\mathbf{H}$ in the conductor generated by $\mathbf{f}$, and that the propagation of electrical disturbances in a conductor is like that of motion in a viscous incompressible liquid. It takes place by the process called diffusion. It is the limiting case of elastic wave-propagation, with distortion and dissipation of energy by friction.

We are usually limited to small motions in this analogy, so that the impressed forces should not act in one sense continuously, but should fluctuate about the mean value zero, for the reason mentioned before. But we are not always limited to small motions. In certain symmetrical distributions of magnetic force and current we may remove this restriction altogether. In the liquid case (333) p strictly means $\delta/\delta t$, whilst in (332) it means d/dt. In the former a moving particle is followed; in the latter we keep to one place. But in the cases of laminar flow referred to, $\delta/\delta t$ reduces to d/dt readily enough, so that the analogy is carried on to cases of steadily acting impressed forces.

The analogy is an important one, owing to the readiness with which the setting in motion of water by sliding friction can be followed, as when a wind blows over its surface. Two interesting cases are the penetration of magnetic induction and (with it) electric current into a core enveloped by a solenoidal coil, in whose circuit an impressed force, variable or steady, acts; and the penetration of magnetic induction and electric current into a straight wire when an impressed force acts in its circuit. Considering the latter we may state the analogy thus. Understanding, in the first place, that the circumstances should be such that the influence of electric displacement outside the wire is negligible, we may replace the wire by a similar tube of water, and then replace the impressed voltage in the electric circuit by a uniform tangential drag upon the surface of the water in the direction of the length of the pipe. The current of water in the pipe and the electric current in the wire, will vary similarly under the action of similarly varying impressed forces. Thus, a steadily applied force on the water will first pull the outermost layer into motion; this, by the viscosity, will pull the next layer, and so on up to the axis. The initial current is purely superficial; a little later we have a central core in which the water is practically motionless, surrounded by a tubular portion whose outermost layer is moving rapidly, and innermost very slowly; later still, the whole mass is in motion, though less rapidly at the axis than at the boundary; finally, the whole mass of water acquires a state of uniform motion. Substituting electric current for current of water, we obtain a representation of the way the electric current is set up in a wire, passing through the various stages from the initial surface current to the final uniformly distributed current. If the impressed force be rapidly oscillatory, we stop the penetration as above described in its early stage, so that if the frequency be great enough, there is a practical confinement of the current (in sensible amount) to the skin of the wire (or of the water respectively). But if the mean value of the oscillatory force be not zero, it is the same as having two impressed forces, one steady, the other periodic, without any bias one way or the other. Then we have finally a steady current throughout the wire, *plus* the oscillatory current with superficial concentration.

When a straight core is magnetised in a solenoid, it is the magnetic induction which is longitudinal, or parallel to the axis. Comparing this with the current of water in the pipe, we have the same state of things as before described, as regards the penetration of magnetic induction into the core.

One effect is to increase the resistance of a wire when the frequency is great enough. It will be remembered that Prof. Hughes (in 1886) brought forward evidence of this increase, and, therefore, in the opinion of others, of the truth of the theory of surface conduction along wires under certain circumstances which was advanced by me a year previous. There has since been plenty of confirmatory evidence of a more complete nature; that is, not merely of an approximation towards, but of an almost complete attainment of surface-conduction.

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This action of conductors is sometimes referred to as magnetic screening. It should, however, be noted that the screening is done by the conductor itself, not by the currents "induced" in the outer part of the wire or core, which are, as it were, merely a sign that the screening is taking place. The screening action often seems to be merely superficial; but this is accidental, from the disturbances being communicated to the conductor from without. In reality, any and every part of a conductor is screened from the rest by the portion immediately surrounding it, that is, by its skin, and by that only. It is primarily the conductivity that causes the screening, so that it is rather conductive screening than magnetic screening. The result is that disturbances can only pass through a conductor by the (relatively) very slow process of diffusion, so unlike that by which they are transferred through a non-conductor. But the property of conductivity acts conjointly with the inductivity, so that although copper would be the best screener on account of its high conductivity, the great inductivity of iron usually far more than compensates for its inferior conductivity, and makes iron take the first place as a screener.

§ 150. As we were not able to make an analogy with c and k both finite, likewise n_0 and n_1, when $\mathbf{H}$ was taken to be velocity, let us try the effect of taking $\mathbf{E}$ to be velocity, as in § 147. Change the source from $\mathbf{f}$ to $\mathbf{g} = -\operatorname{curl}\mathbf{h}$; then we have merely to alter cp in (328) to $k+cp$ to obtain the required modification. Thus,

$$\mathbf{g} = \left((k+cp) - \frac{\nabla^2}{\mu p}\right)\mathbf{E} = \left((kp+cp^2) - \frac{\nabla^2}{\mu}\right)\mathbf{A}, \quad . \quad (334)$$

if $\mathbf{A} = \mathbf{E}/p$. Here, again, on comparison with (329), we see that distortional friction will not furnish a proper analogy in the general case. There seem to be but two special cases possible; first, with the conductivity and frictionality both zero (not the resistivity and frictionality), which reproduces the case in § 147; and, secondly, the permittivity and the rigidity both zero (not permittivity and compliancy), which brings us to the viscous liquid again. Thus, putting $c=0$ in (334) brings us to

$$\mathbf{g} = \left(kp - \frac{\nabla^2}{\mu}\right)\mathbf{A}, \quad . \quad . \quad . \quad . \quad . \quad (335)$$

which compares with (333). We now compare conductivity with density, and inductivity with the reciprocal of the viscosity. This is by no means so useful as the previous form of the viscous fluid analogy, although it is fundamentally of the same nature, involving propagation by diffusion.

As in §§ 146, 147, we had a failure of representation of one of the energies by the energy of distortion, so now, in the viscous fluid analogies, we fail to represent the dissipation of energy properly. This depends, as shown before, on the velocity of distortion, so we might expect a similar failure.

§ 151. But we can get a working analogy to suit the conducting dielectric in another way. Thus, still keeping the distortional elasticity or rigidity, give up the viscosity or distortional friction, and substitute translational friction. For the equation of motion of an incompressible solid with the usual constants, rigidity n and density ρ_2, and with translational frictionality ρ_1 is

$$\mathbf{f}_1 = (\rho_1 p + \rho_2 p^2 - n\nabla^2)\mathbf{G}, \quad . \quad . \quad . \quad . \quad (336)$$

where $\mathbf{f}_1$ is circuital impressed force. Now operate on (331) by $1 + k/cp$, producing the equation

$$\left(1 + \frac{k}{cp}\right)\mathbf{f} = \left(\frac{\mu k}{c}p + \mu p^2 - \frac{\nabla^2}{c}\right)\mathbf{Z}. \quad . \quad . \quad (337)$$

Comparing this with (336) we see that there is a proper correspondence of form on the right sides, though not on the left. The circuital impressed force $\mathbf{f}_1$ is replaced, not by $\mathbf{f}$, but by $\mathbf{f} + k\mathbf{f}/cp$. This is awkward for the analogy as regards the generation of disturbances. But away from the sources, there is a useful correspondence. As in § 146, $\mathbf{Z}$ corresponds to spacial displacement in the solid, $\mathbf{H}$ to velocity, μ to density, c to compliancy (distortional); whilst now, in addition, the translational frictionality in the solid has the complex representative $\mu k/c$ in the dielectric; or $k(\mu v)^2$, if v is the speed of propagation of disturbances. So disturbances of $\mathbf{H}$ are propagated in the same way through a conducting dielectric, as are disturbances in an incompressible solid with the usual rigidity, with frictional resistance to displacement superadded. But we do not correctly localise the energy dissipated. The rate of waste per unit volume is $k\mathbf{E}^2$ in the dielectric, whilst it is $\rho_1\mathbf{q}^2$ in the solid, which corresponds to $k(\mu v)^2\mathbf{H}^2$ in the dielectric. This being entirely against Joule's law renders this form of analogy unsatisfactory. But we may easily make a substantial improvement by taking $\mathbf{E}$ to be velocity in the solid.

§ 152. Thus, let $\mathbf{g} = -\operatorname{curl}\mathbf{h}$ be the source of disturbance in the dielectric, so that we have the equations (334) to consider. Take the second form and compare it with (336), and we see at once that there is a considerably more simple correspondence than in the case last treated. Thus, the source $\mathbf{f}_1$ of circuital displacement $\mathbf{G}$ corresponds to the source $\mathbf{g}$ of circuital $\mathbf{A}$ (the time-integral of $\mathbf{E}$); the electric force now means velocity; μ is compliancy; c is density; k itself is the frictionality; the electric energy $\frac{1}{2}c\mathbf{E}^2$ is kinetic energy; and the waste (Joulean) is properly localised in the solid by the frictional waste of energy $\rho_1\mathbf{q}^2$ per second. The induction $\mu\mathbf{H}$ is twice the rotation. In fact, this case is the same as in § 147, with translational friction added without destroying the analogy. It is clear that the correct localisation of the waste, and the correspondence of sources, makes the analogy be more readily followed. Of course, there is the same failure as regards the distortional energy as in § 146.

§ 153. As a last example in which use is made of distortional elasticity, let us generalise the non-conducting dielectric by the introduction of magnetic conductivity. We have

$$\operatorname{curl}(\mathbf{H} - \mathbf{h}) = (k+cp)\mathbf{E}, \quad . \quad . \quad . \quad (338)$$

$$\operatorname{curl}(\mathbf{e} - \mathbf{E}) = (g+\mu p)\mathbf{H}, \quad . \quad . \quad . \quad (339)$$

where g is the magnetic conductivity. So, if $\operatorname{curl}\mathbf{h} = 0$, and we eliminate $\mathbf{E}$, we have

$$\operatorname{curl}\mathbf{e} = \left((g+\mu p) - \frac{\nabla^2}{k+cp}\right)\mathbf{H}. \quad . \quad . \quad (340)$$

Or, if $\operatorname{curl}\mathbf{e} = 0$ and we eliminate $\mathbf{H}$, we have

$$-\operatorname{curl}\mathbf{h} = \left((k+cp) - \frac{\nabla^2}{g+\mu p}\right)\mathbf{E}. \quad . \quad . \quad (341)$$

We see that we cannot, when k and g are both finite, get a satisfactory analogy as regards the generation of disturbances by $\mathbf{f}_1$, circuital impressed force in a solid. Consider, therefore, only the free propagation, subject to the equation

$$0 = \left((k+cp)(g+\mu p) - \nabla^2\right)\mathbf{Z}, \quad . \quad . \quad (342)$$

where for $\mathbf{Z}$ we may substitute $\mathbf{H}$ or $\mathbf{E}$ or other electrical quantities. Since, in (342), we have a term proportional to $\mathbf{Z}$ itself (or its substitute), we must introduce elastic resistance to displacement in the elastic solid to make an analogy. Thus,

$$\mathbf{f}_1 = (\rho_0 + \rho_1 p + \rho_2 p^2)\mathbf{G} - n\nabla^2\mathbf{G}. \quad . \quad . \quad (343)$$

is the equation of motion in the incompressible solid if there be elastic and frictional as well as inertial resistance to translation, by (307), (313), § 145.

Now expand (342) and divide by c. We get

$$0 = \left(\frac{kg}{c} + \left(g + \frac{k\mu}{c}\right)p + \mu p^2\right)\mathbf{Z} - \frac{\nabla^2}{c}\mathbf{Z}, \quad . \quad (344)$$

which is suitable for comparison with (343). When $\mathbf{Z}$ is the spacial displacement, $\mathbf{H}$ is velocity, c compliancy, μ density, as in § 146; but in other respects the correspondence is complex, for the elastic resistance to translation ρ_0 is kg/c, whilst the frictionality ρ_1 is $g + k\mu/c$.

If we take $\mathbf{E}$ to be velocity there will be another set of correspondences, c being density and μ compliancy.

However unsatisfactory the analogy may be in details, we have still the result that disturbances in a dielectric with duplex conductivity (electric and magnetic) are propagated similarly to motions in an elastic solid constrained in the manner above described. The effect of the two kinds of distortion and waste of energy involved in the existence of the two conductivities are therefore imitated by one kind of frictionality in the elastic solid.

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The singular distortionless case comes about when

$$\left.\begin{array}{ll} \rho_0\rho_2 = \rho_1^2 & \text{in the solid} \\ k/c = g/\mu & \text{in the dielectric.} \end{array}\right\} \quad \ldots \quad (345)$$

In either case the effect of the frictional resistance on the disturbances is made merely attenuative. Disregarding the attenuation with the time, the propagation takes place in the dielectric in the same way as if it were non-conducting, and in the solid in the same way as if it were devoid of frictional resistance. In the electromagnetic case we may follow this into detail with ease in a symmetrical manner. It is, however, rather troublesome in the elastic solid, on account of the want of correspondence in detail, due to the employment of distortional elasticity, and for other reasons.

(To be continued.)

THE DIMENSIONS OF PHYSICAL QUANTITIES.

BY W. M. M.

The publication last month of Mr. Williams' Paper "On the Relation of the Dimensions of Physical Quantities to Directions in Space," and the impending discussion thereon at the Physical Society, has raised afresh the recurring question as to the meaning of these dimensional equations, and the cognate question of the products and powers, integral, negative, and fractional, of concrete quantities.

There has always been a considerable body of mathematicians and physicists who have utterly refused to take what Mr. Williams calls "a most comprehensive and fundamental view of the matter." To these the dimensional formulæ remain still, what by general consent they are primarily, numerical relations between the units. They admit that they have no clear conception of the process of multiplying a force by a length, though they fancy they have a very clear conception of "a couple" and of "work;" and they even venture to doubt if anyone else really can picture to himself the square root of the product of a length into a mass. They have, however, for the most part, been content to wait in silence, expecting the pioneers of this new philosophy either to establish their position or to abandon it. They wait in vain. The so-called physical equations are neither admitted to be mere "change ratios," nor satisfactorily shown to be something more. They are *assumed* to be more, and the difficulties which inevitably arise are attempted to be met by fresh elaborations, such as giving a physical meaning to coefficients which are originally, by definition, numerical quantities, as μ, k, and even π.

Were the matter in debate primarily a physical or mathematical question, the authority of Lord Kelvin, the foremost physicist, and one of the foremost mathematicians of our day, would be almost conclusive. We say *almost*, for in science we admit of no pope, however eminent, and not the least of the many debts we owe to Dr. Oliver Lodge is his practical demonstration that, even on a physical question, Lord Kelvin's authority may be successfully opposed. But we hope to be able to show that this is not really a physical question at all, but a question of language and logic; and, though a mathematician is likely to be a sound logician, he is by no means necessarily so.

Ratio is defined by Euclid as "the relation between two quantities *of the same kind* in respect of magnitude." It follows that in order that two quantities may be equal (*i.e.*, bear one to the other a ratio unity) they must be of the same kind. Hence, in such an equation as $s = \frac{1}{2}ft^2$, either the symbols employed must be numerical quantities, or, if they are concrete, since s is a length ft^2 must also be one.

Now, it is admitted on all sides that, in the primary sense of the words, the statement that *an acceleration multiplied by the square of an interval of time is equal to a length*—is nonsense; it is using words whose corresponding ideas will not go together. But the suggestion is that, as Clifford said in a similar case, we should "treat it as if it were sense, and see what comes of it." This method is by no means new, nor do we think it always deserves to be described as "logically false and educationally mischievous."

When applied to the multiplication of fractions in arithmetic, or the interpretation of negative and fractional indices in algebra, "what comes of it" is a modification of our definitions in such a way that what seemed nonsense becomes sense. The question then arises, can any definition of multiplication be framed which will cover such cases as the above? If it can be, it is remarkable that it has never been done, though an attempt in that direction was made four years back by Prof. A. Lodge. But, even if it were done, it is doubtful if there would be any great advantage to be derived from it, since every equation is equally intelligible without such a refinement.

But we doubt altogether the possibility of framing such a definition. Recollect that it must be such as to cover every case. Thus—Economists used to tell us that the number of marriages in a community varies as the price of corn. (Whether they were stating a true law is not to the purpose.) It is clear that by a proper choice of units this variation may be made into an equation; but who would venture on the task of constructing the dimensional equation which would make this a relation between concretes? But we are unwilling to pursue this line of argument. The *reductio ad absurdum* method is a valid one in geometry, for the absurdities there appealed to can be appreciated without the aid of a sense of humour; but burlesque is altogether wasted on those who, with Professor Garnett, can gravely state the dimensions of *price* in *oranges*.

But suppose we agree, without waiting for an extended definition of multiplication, to treat nonsense as sense, and see what comes of it. We get from one definition of unit force that force is of dimensions MLT^{-2}. From another definition it is of dimensions M^2L^{-3}, and both definitions are equally admissible. Is it not clear from this that the dimensional formulæ do not "represent the *physical identities* of the various quantities," but only indicate at most the conventions we have adopted, as to our system of units and our mode of measurement. Similarly *resistance* comes out as either a *velocity* or a *slowness* according to the system adopted; it clearly cannot be both, but it may very well be neither.

But much worse than this "comes of it." It has been well said that "mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends on what you put in." Into our electrical and magnetic dimensional formulæ we put—the assumption that our units shall be systematic; the law of the inverse square as true for static charge and for magnetic poles; the fact that an electric current produces a magnetic field, also following the law of the inverse square; and the unproved assumption that a current is a *flow* of whatever causes static charge. What we get out changes from day to day, but at present it includes—that electricity is ether, that resistance is a velocity, and that the coefficient of self-induction is a length. Respecting the last point it may be noted that the tone of our opponents has changed somewhat. Formerly they were almost apologetic, and spoke of resistance as "of the nature of velocity," whatever that may mean. Now they are very positive. "But it"—*i.e.*, self-induction—"*is* a length," as one of them said at the last meeting of the British Association.

We wonder whether this impatient dogmatism covers secret misgivings. We almost think it must be so, for at the commencement of the discussion on Mr. Williams' Paper the same gentleman alluded, in a tone with which we entirely sympathise, to the absurdity of trying to attach any physical idea to such expressions as $M^{\frac{1}{2}}$ or $L^{\frac{1}{2}}$. But when he added that the *only* way out of the difficulty was on the lines that Mr. Williams laid down, we were no longer with him. It seems strange that it never even occurred to him that while the square root of a *mass* was unintelligible, the square root of a *ratio* presents no difficulties whatever.

To sum up. We quite admit that a physical quantity consists of two parts, its measure and its concrete unit; but we deny that, in general, the latter can enter into an equation. We do not object to the equation $s = v\,t$ being written $s[\mathrm{L}] = v[\mathrm{V}]\,t[\mathrm{T}]$, but we deny that [L], [V], [T], are, *in this equation*, concretes. They are the numerical measures of our units in terms of new units. We do not object to suppressed dimensions, for we prefer to suppress them all. We regard these physical

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equations as a hindrance instead of a help in education, since they are one more step in the direction of making our symbols do our thinking for us; and of this there is already too much in mathematics. It is noteworthy that the enthusiasts for these methods almost always complain that "students usually find peculiar difficulty in questions relating to units." We are not surprised, nor do we think it is altogether the fault of the students. We never met anyone so dull that he could not understand the proverb, "The more the merrier, *the fewer the better fare.*" Yet the latter part of this expresses exactly the same idea as the more pretentious sentence, "The numerical value of a concrete quantity varies inversely as the unit in terms of which it is expressed."

NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 214.*)

14. Cable Splice.—Before the splice in the sheathing wires is made, the core is served with a layer of tape or loose spun threads, over which is laid a serving of brass tape, followed by jute, yarn, or Russian hemp, bound at intervals with seizings of fine yarn. The splice is then begun on the right side, laying the wires close together by means of the splicing tool (Fig. 44). This tool is made in steel plate, with notches in the form of two half circles, in which the sheathing wires are placed. The tool is opened in the middle to set it in position across the cable and put the wires in order in their respective notches, and is then closed up and fastened by a small set screw and nut. It is then worked round by the handles in the direction of the lay, and in this manner the wires are forced round the cable in their proper places spirally, exactly similar to the other part of the cable. Little by little as the tool is worked round it is pushed forward along the cable; for example, in the deep-sea type the lay of the sheathing wires being ten inches, the tool would advance ten inches for one complete turn round cable. With steel wires the work is much more difficult than with galvanised iron, as the spring of the steel exerts a considerable resisting force to the twist. As the tool is worked along it is followed up in places by seizings of yarn round the cable to keep it from springing back.

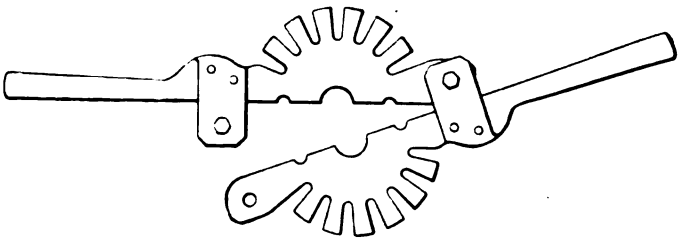

Fig. 44.—Splicing Tool.

In Fig. 45 this tool is shown in position as used, the sketch representing the operation as nearly completed on the right wires. As soon as the tool is worked round to the end of the wires, that is, to where the left wires are unlaid, a final seizing is put on about 4in. from the end, and the tool removed. With a hand-cutting tool the ends are then snipped off perfectly equal in length. The left wires are now taken in turn, and every two wires alternately if small, or every one alternately if large wires, are snipped off short, so as to exactly butt the ends of the right wires. The alternate pairs of wires remaining on the left side, which are all about 90ft. in length, are then laid in turn on the right side, corresponding pairs of right wires being unlaid to receive them. Take, for instance, one such pair. It is first of all noticed which pair of right wires lies in the same lay as the pair of left wires we are considering. This pair of right wires is then unlaid for some distance, say 50ft., and the corresponding pair of left wires threaded in under the seizings, so as to lay in the place thus vacated for them. One wire of the left pair, and one wire of the right pair, which lie in the same lay, are then snipped off so that their ends lie exactly butt together. The single right wire that remains is

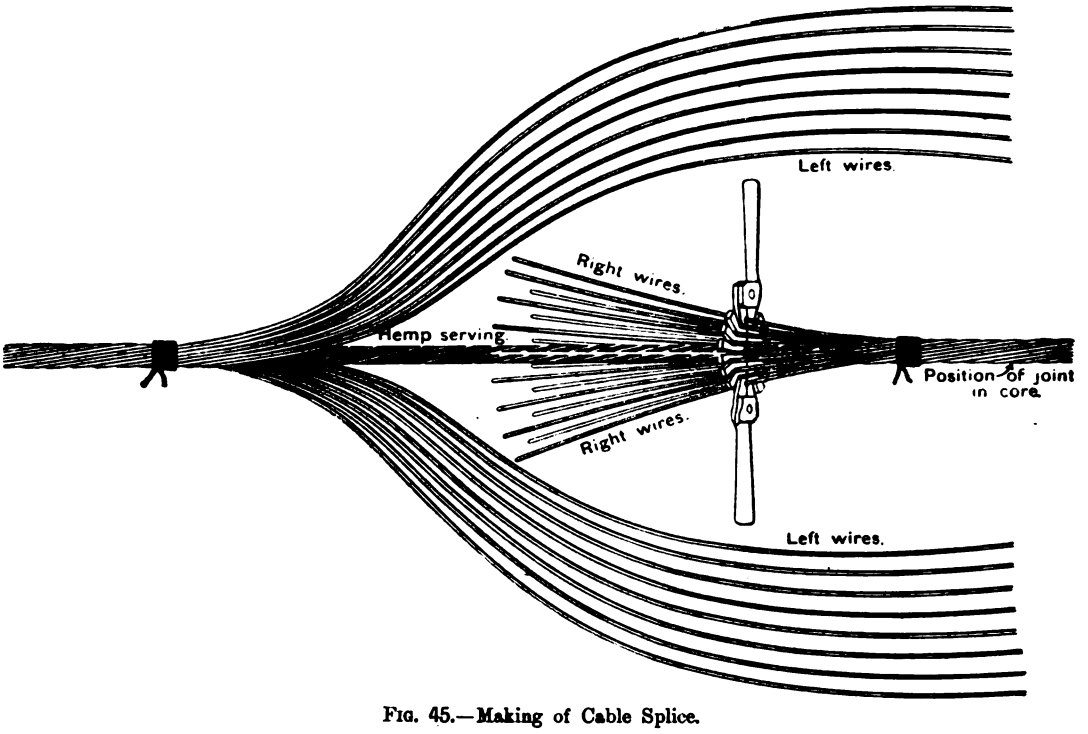

Fig. 45.—Making of Cable Splice.

Fig. 46.—Finished Splice in Sheathing Wires.

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then further unlaid, and is followed up by the remaining left wire, which is laid in the place vacated by it. This is continued for about 40ft. further, when the ends of both wires are snipped, so as to lie butt together. The next pair of wires is then taken and treated in the same manner; this time the wires being cut at shorter distances than the above, so that the butted ends do not all lie near together. The next pair follows, and the wires are cut at still shorter distances than the preceding ones, and so on to the last pair; the procedure in this respect

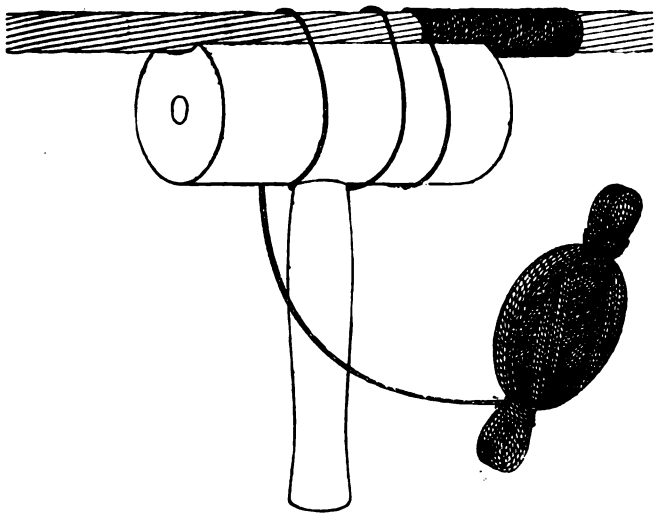

Fig. 47.—Serving Mallet.

being similar to that in manufacture, when no weld in any of the sheathing wires is allowed to be nearer than ten feet to any other weld in the same or any other wire. With the left wires 90ft. long as given above, and with 16 sheathing wires as shown in the illustration, there would be eight wires carried over on to the right side, and the butt joints between these and the right wires would be at distances of about 11ft. apart.

The appearance of the splice so made is represented in Fig. 46, where the left wires are shaded, so that their course can be traced and understood. Necessarily, in the sketch, for want of room, the splice is shown much shorter in length relatively to the size of cable and sheathing wires than it should

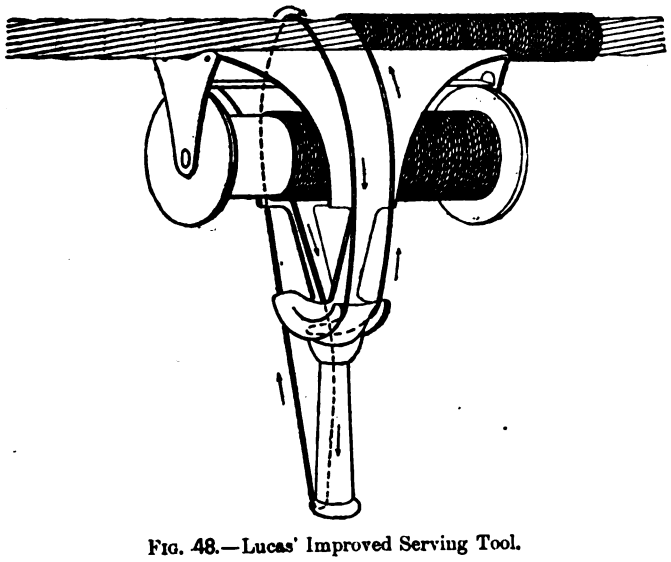

Fig. 48.—Lucas' Improved Serving Tool.

be, but it serves the purpose of making the manner of splicing understood. In splices made at the factory between very different types of cable such as the deep-sea and intermediate portions, the sheathing wires of the larger cable are tapered down to the size of the smaller. Apart from the great length of the cable splice, so made for the purpose of distributing the strain, it will be noticed that it differs from the sailor's rope splice, in which he remembers he must—

"Worm and parcel with the lay,
Turn about and serve t'other way."

Again, it will be noticed that the joint in the core is covered by the pairs of right and left wires laid together, and is some distance away from the place where the alternate pairs butt. Over all butts are wrapped seizings of ductile wire.

It now only remains to cover the whole with a serving of tarred yarn. For this purpose the serving mallet shown in Fig. 47 has long been in use. The mallet is represented in the sketch in position for serving, one man turning the mallet round by the handle while his mate follows round with the ball of yarn. Pairs of men are stationed along the splice, who commence serving at different points, and continue till they finish where their neighbours began, so covering the whole. The course of the yarn from the ball round the body and handle of the mallet to the cable is shown clearly in the sketch. By the half turn taken round the root of the handle, the round turns over cable and mallet are in opposite directions, which causes sufficient check on the yarn to render it taut on the cable.

An improved serving mallet has been introduced by Mr. F. R. Lucas, of the Telegraph Construction and Maintenance Company, which can be worked by one man. This is made in metal, and carries on a reel its own supply of spun yarn (Fig. 48). From the reel the yarn passes through the hollow handle, then round the cable, and back to the mallet, where it takes half a turn round the shank to keep it taut, and then returns to the cable in the opposite direction, round which it is fed in a continuous spiral as long as the mallet is turned round. The splice, which may have occupied altogether two hours, is now complete, and after a final test through is ready to be dropped overboard.

(*To be continued.*)

RESISTANCE STANDARDS.*

The author considers that the standard of resistance is the most valuable that we have, being the only one that has any physical tangible existence. The wire for standard coils should have high specific resistance to avoid large bulk, and as small a temperature coefficient as possible; it must not change with time either from oxydation or other cause, and it must be of a hardness suitable for handling in manufacture without injury. These requirements at once throw out all pure metals, and compel us to have recourse to alloys. The B.A. Standards Committee, after exhaustive experiments from 1862-5 on various metals and alloys, finally concluded that silver alloyed with 33·4 per cent. of platinum was the best for the purpose, and it is still largely used; its specific resistance is, the author says, 14 microhms, and its T.C., 0·031 per cent. (or under one-tenth that of copper, not one-hundredth as the author puts it). Many metals seem to alter in resistance with time and heating. Bergman in 1889 kept various metals at 300°C. for an hour and found that they had all altered, copper having decreased 2·4 per cent. and German silver increased 0·2 per cent. The platinum silver standards of the B.A. Committee were found last year to have increased about 0·06 per cent. The committee suggest that this change is due to strains in lowering the coils to 0° for the test. Time changes, however, do undoubtedly occur in metals even when not subjected to any such stresses. Winding a wire on a bobbin necessarily changes its form somewhat and also its resistance, and such strains take a long time to settle down; for which reason coils have to be kept some months before final adjustment.

The author then refers to platinoid, which he says he has several times analysed, but in which he has never found any of the two per cent. of tungsten which it is said to contain. Be this as it may, it has the properties claimed for it, a T.C. of 0·022 per cent. (not $\frac{22}{100}$ as said), and a specific resistance of 32 microhms.†

The author then refers to a new wire sent him by the Aluminium Brass and Bronze Company of Bridgeport, Conn., which is claimed to have a specific resistance of 56 and a T.C. of less than 0·004. It appears to contain a considerable amount of copper, and is possibly about 70 copper to 30 manganese, with perhaps a little nickel. Drs. Feussner and Lindeck (*Zeits. Instrk.* Feb. 1891) state that an alloy of 70Cu and 30Mn has a negative T.C. of 0·003 per cent. So that it appears probable that an alloy may be got with a zero T.C., a consummation devoutly to be wished.

* Abstract from a Paper by E. G. Willyoung before the Franklin Inst.

† The T.C. (temperature constant) varies from 0·017 for very fine wire to 0·025 for wires of 0·02in. to 0·03in. The T.C. does not follow the size in any exact law, but the connection is unmistakable. The specific resistance also varies. I have generally found it to average about 38 or 39, but it varies from 30 to 45.—C.W.S.C.

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TESTS OF EDISON-SWAN LAMPS.

A large number of tests of the candle-power, efficiency and resistance of glow lamps have been made both in the United States and on the Continent, and have served a useful purpose in showing the general character and properties of different kinds of lamps. But it is remarkable that while in this country we have been tied so exclusively to one make of lamp, and one only, no tests of that lamp have been published. That the publication of such data has not been encouraged by the makers can have little to do with the absence of any such literature, and it can only be explained by the well-known fact that what is everybody's business is nobody's business. In the recent LANE-FOX action, some figures showing the candle-power and life of lamps, presumably of EDISON-SWAN make, at different voltages, were given by one of the witnesses. The life of lamps is fully as important as their candle-power, since these two factors enter into the total cost of lighting; but accurate determinations of life cannot be arrived at except by very considerable trouble, even if assisted by meters, and no one, so far as we know, has attempted to carry out really careful and complete experiments on the duration of lamps at higher or lower voltages than the normal. Not only must such observations of necessity be spread over a considerable period, but they must be carried out on a sufficiently large number of lamps to ensure a fair average. For it is well known that out of a number of lamps which agree well together in candle-power at any given voltage, and which in fact do what the makers' marks say they will do; the life, that item about which the makers say nothing, may vary enormously. Some lamps will give out in the first twenty or thirty hours, and others will have a phenomenal existence. Much more care should, therefore, be taken in examining the life of lamps, to eliminate accidental values, than is needed in measuring those characteristics which are a simple matter of laboratory work. Besides the actual life of the lamp as a lamp, there is the very important question of the gradual change in the candle-power, culminating at a point at which it is better to throw the lamp away than to continue to burn it at a low efficiency.

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Electrical engineering, as we recently observed, is becoming desperately scientific, and we expect to see every physical quantity expressed in figures, and every physical fact in a formula. From one point of view, a knowledge of the candle power of a glow lamp at a given voltage, and its life at that voltage, seems a perfectly indispensable starting point in dealing with the cost of electric lighting; so indispensable, in fact, that not only elaborate experiments ought to be made, but a considerable amount of theory is warrantable. But we have a bare theory of minimum expenditure, and no data whatever for applying it. On the other hand, it might be imagined by a sufficiently thoughtful and ignorant person, that a manufacturing engineer would have an accurate knowledge of tool-speeds, drill-feeds, and the life of tools and the cost of grinding them. But most of them trust their foremen to see after these details, and not a few foremen leave such matters where they found them, picking up occasional hints about the possibilities of tool-speed on piecework, and merely avoiding extremes in the matter of grinding. So with glow lamps, we have been content to do without accurate knowledge, and to trust the makers. The makers of the glow lamp, to which patent laws have tied us for so many years, may indeed flatter themselves that when we ask for a 16-candle lamp, we do not "see that we get it," but we take their word for it, and we are equally accommodating in the matter of durability, about which no promise whatever is made.

Tests of ordinary EDISON-SWAN lamps have been carried out by some students at the Central Institution, a report was drawn up by them at Easter, 1891, and we are enabled by the kindness of Prof. AYRTON to publish the results in our present issue. It should be observed that the lamps were of the ordinary pattern, bought from the EDISON-SWAN Company in the usual way, and tested at once while quite new. Several previous tests of glow lamps had been made at the Central Institution, and it is easy to see from the report that the students had a competent knowledge of the use of the apparatus, and that their results may be accepted with confidence. Several sheets of curves accompany the report, and some of these are reproduced, but we can only find space for a few of the actual observations as samples. It will be observed that the stated figures are not borne out by the tests. Lamp No.2 02, bought as a 100-volt lamp, appears to be better adapted for 105 volts. It would be a pleasure to publish such an abstract as this if only to show what careful work is being done under Prof. AYRTON; but the information contained in it is of very considerable interest even to the most rule-of-thumb electrician, and the fact that the first patent of those which lock up the lamp-making industry expires in some eighteen months, makes the publication of these results of no less importance.

OBITUARY.

MR. CYRUS WEST FIELD.

We regret to record the death of Mr. Cyrus West Field, in his 73rd year, at New York, on the 12th instant.

The world has grown so accustomed to the constant interchange of submarine cable messages that there is some little likelihood of the important part which he played as the pioneer of ocean telegraphy being overlooked. It is not too much to say that, had it not been for his bold conception of bridging the Atlantic by the electric wire, and the marvellous energy which he displayed in practically giving effect to the idea, telegraphy under the greater oceans would have been carried out many years later than it actually was.

The late Mr. Field was one of the several sons of Dr. David Dudley Field, D.D., who himself was born in the State of Connecticut—almost simultaneously with the recognition of the United States as a Republic—in 1781. The eldest son, who bears his father's name, is still living, and is one of the foremost jurists the New World has yet produced. Another son, Mr. Stephen Johnson Field, became Judge of the Supreme Court and, finally, Chief Justice of California. Another of the late Mr. Field's brothers is the Rev. Henry Martin Field, who was editor and proprietor of *The Evangelist*, of New York, as well as author of several books, including "A History of the Atlantic Telegraph," "A Chronicle of the Irish Rebellion of 1798," and a History of Rodney's successful Defence of Gibraltar. The most famous son, however, of the Rev. Dr. Field was the indefatigable "promoter" of the Atlantic cable. Born in Massachusetts in 1819, and educated in his native State, he was the only member of the family who was brought up to a commercial life. At the age of fifteen he went to New York, and commenced his business life in the colossal dry goods stores of Alexander T. Stewart. When just twenty-one he began on a large scale the manufacture and sale of paper. Having established a large and increasing business, at the age of thirty, when travelling in South America, he conceived the idea of connecting Europe with Newfoundland, and the latter island with New York by submarine cable. Assisted by four of the most influential capitalists in New York, Mr. Peter Cooper, Mr. Moses Taylor, Mr. Marshall O. Roberts, and Mr. Chandler White, he showed the most indefatigable energy and persistence until communication was accomplished in 1858. He crossed the Atlantic some fifty times, and interviewed everyone likely to assist in carrying out the enterprise, including the late Mr. John Bright and Mr. Gladstone — the former of whom said that Mr. Field was "the Columbus of modern times, whose cable had moored the New World alongside the Old." Even when the cable, after working only a month, ceased to transmit messages, the late Mr. Field did not lose a jot of heart or hope, or abate the truly extraordinary energy and pertinacity of his efforts. The repair of cables in deep water was then thought to be impracticable, and Mr. Field was unceasing in his efforts to get a new cable manufactured and laid. In 1865 another effort was made to lay a cable, but the end being lost and no adequate apparatus for raising it existing, the attempt had to be abandoned. In the following year, 1866, the third cable was successfully submerged, and later in the same year the lost cable of 1865 was picked up and completed. Had Mr. Field been an English citizen, honours and decorations would have been offered him on this side of the Atlantic. At home the United States Congress voted him a gold medal for his exertions connected with Atlantic telegraphs; while a dinner was given in his honour at Willis's Rooms, London, when telegraphic messages were exchanged between the company present on the one side and Lord Monck, Viceroy of Canada, and President Johnson on the other. Mr. Field was a Director of the Atlantic and Anglo-American Telegraph Companies, as well as of the Falmouth, Gibraltar and Malta, the Anglo-Mediterranean, and the Globe Telegraph and Trust Companies. Mr. Field was also one of the earliest advocates of a trans-Pacific cable, which has not, however, yet been carried out.

Shortly before his death Mr. Field was interesting himself in a project for laying a cable from San Francisco to Honolulu, with a subsidy from the American Government, as the first section of a submarine cable to Australasia and Japan. He also advocated the formation of a giant company to absorb all the submarine cable companies in the world, which was not however destined to be realised. Mr. Field became an American millionaire, and for many years fortune seemed to smile upon him; but in November last he was prostrated by the death of his wife, who had lived to celebrate their golden wedding, and soon after he was almost ruined by the failure of his son's firm of stockbrokers, his son becoming insane. These troubles, together with the dangerous illness of one of his daughters, broke down Mr. Field's health; and after a long illness death ended a remarkable career, which illustrates the power of the man of a single idea, and entitles the late Mr. Cyrus West Field to be regarded as one of the great benefactors of mankind.

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TESTS OF GLOW LAMPS.

The following is an abstract of a report on the efficiency, resistance, and candle-power law of six perfectly new Edison-Swan lamps, Nos. 200 to 205, drawn up by Mr. G. C. Turner, Mr. Lloyd, and Mr. Wicks, at the Central Institution of the City and Guilds of London, and dated at Easter, 1891. This report is a sample of a number which Prof. Ayrton's students have made on incandescent lamps of various types constructed in England and abroad :—

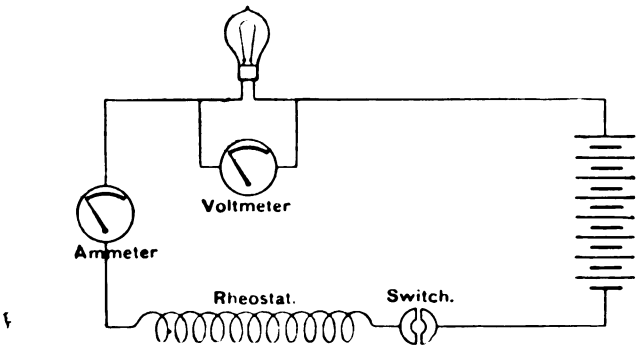
As in previous experiments on incandescent lamps, the standard of light was a Methven screen of 2 c.p., previous tests having shown that this agreed extremely well with the Harcourt's pentane standard. Distance between standard and lamp to be tested was 200 centimetres. Photometer used was a paraffin block photometer. During the experiment a series of observations were made to determine the errors of (1) reproduction ;* (2) photometer error ; (3) personal error. The test was made with lamp No. 203.

(1) Reproduction error.—Mean error was found to be 0·195 centimetre, which, as a percentage of the length of the bench, gives per cent. of error* = 0·097.

(2) Photometer error.—Mean error = 2·4 centimetres, *i.e.*, 1·2 per cent. of length of bench.

(3) Personal error.—Mean = 1·93 centimetres ; per cent. of error = 0·96.

The voltmeter was always placed as a shunt to the lamp, and the ammeter reading corrected for current passing through the voltmeter. In all cases when photometer readings were not taken by all three observers, the readings were corrected for personal error, so as to get approximately the reading which would have been obtained if all three had taken readings. In



all cases readings were taken first with photometer blocks facing one way, then with them facing the opposite way, so as to eliminate the error due to the blocks being unsymmetrical, or non-central. In all cases the readings given are the mean of three or four readings.

It was noticed that whenever the lamp had to be taken off so as to change the number of accumulators, the current, on putting lamp in circuit again, had decreased. Hence, it would seem that in order to take the readings so as to bring the lamp into a normal state for that reading the volts should be kept constant for some time before reading is taken, in order that the lamp may be in a steady state. In our experiments, owing to the great number of observations to be made, it was impossible to do this completely.

Resistances of the Lamps.

50-volt 8-c.p. lamps: ratio of resistance hot to resistance cold fell from 0·508 to 0·479 as the current was steadily increased.

100-volt 8-c.p. lamps, from 0·546 to 0·496.

100-volt 16-c.p. lamps, from 0·584 to 0·494 and 0·548 to 0·508.

In most cases, especially in the 50-volt lamps, the resistance shows a decided tendency to rise just before the normal voltage is reached. The resistances of these lamps seem to fall considerably more in proportion than is the case with old lamps ; for example, No. 3, for which lamp the ratio of resistance hot to resistance cold only fell from 0·52 to 0·49. The watts per candle at normal voltage varied from 3·8 to 4·0, except in the 100-volt 8-c.p. lamps, in which it went up to 5, showing a decided inferiority in the 8-c.p. lamps as regards cost of supply.

The candle-power of a lamp observed by this sort of photometer seems to depend to some extent on the exact part of the lamp bulb which faces the paraffin blocks, the inequalities of the glass having considerable influence on the observed candle-power, an exaggerated case being seen in lamp No. 14, previously tested, in which candle-power was doubled by the lamp being placed edge on instead of at an angle of 45deg. This would probably explain some of the irregular results obtained in the life test.*

Lamp No. 200.

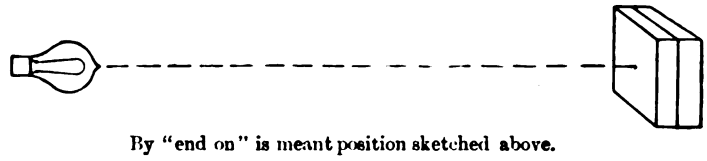
Nominal volts, 50, Candle-power, 8. Single thin filament. Resistance when cold, 162·3. Carpentier galvanometer used as voltmeter, with 6,000 in B.A. box No. 12 + 770 in Harvey and Peak box. Ammeter No. 564. Filament broadside on.

Carpentier reading.	Mean amperes from curve.	Amperes.	Volts.	Watts.	Mean photometer reading corrected.	C.P.	Watts per candle.	Resistance.	Resistance hot. Resistance cold.
1·26	0·392	0·388	32	12·42	145·44	0·25	49·66	82·47	0·5082
1·32	0·414	0·41	33·4	13·7	139·59	0·37	37·01	81·45	0·5019
1·38	0·432	0·427	34·8	14·86	133·37	0·49	30·33	81·51	0·5023

(Sixteen similar observations follow. The results are given on Fig. 1, and are represented by crosses.)

Variations of candle-power with the angle which the plane of loop makes with the photometer blocks, the axis of the lamp being perpendicular to the photometer bench. Volts, 50. Ampere, 0·677 (corrected for curve and voltmeter). Watts, 33·85.

Angle	0	22·5°	45°	67·5°	90°	End on
Candle-power	7·47	7·43	7·37	7·33	7·26	3·21
Watts per C.	4·531	4·555	4·592	4·617	4·662	10·54



By "end on" is meant position sketched above.

Lamp No. 201.

Nominal volts, 50. Candle-power, [8]. Single thin filament. Resistance when cold, 158·3. Carpentier galvanometer used as voltmeter, 6,000 in B.A. box No. 12+770 in Harvey and Peak box. Ammeter No. 564. Filament broadside on.

(Nineteen observations follow. The results are given in Fig. 1, and are represented by circles.)

Variation of candle-power with the angle which the plane of the loop makes with the photometer blocks. Volt, 0·50. Ampere, 0·677 (corrected for curve and voltmeter). Watts, 33·85.

Angle	0	22·5°	45°	67·5°	90°	End on
Candle-power	7·72	7·84	7·57	7·32	7·37	3·68
Watts per candle	4·38	4·31	4·47	4·62	4·59	9·198

Lamp No. 202.

Nominal volts, 100. 16 c.p. Double-loop thin filament. Plane of loop, broadside on. Carpentier galvanometer, with 13,000 in B.A. box No. 12+719 in Harvey and Peak box. Ammeter, Ayrton and Perry permanent magnet voltmeter, No. 567, used as an ammeter.

(Twenty-two observations follow. The results are given in Fig. 2.)

Relation between candle-power and angle which the plane of the filament makes with the plane of the blocks. Volts, 100. Ampere, 0·584. Watts, 58·4.

Angle	0	22·5°	45°	67·5°	90°	End on
Mean corrected phot. reading	55·51	55·37	56·27	57·02	54·36	63·86
Candle-power	13·5	13·6	12·9	12·5	14·2	8·9
Watts per candle	4·326	4·294	4·527	4·326	4·112	6·561

Lamp No. 203.

Nominal volts, 100. Candle-power, 16. Double-loop thin filament. Carpentier galvanometer as voltmeter. Resistance in series with 13,000 in B.A. box No. 12+719 in

[* "Reproduction error" means the error between measurements of any given quantity, when the whole of the apparatus has been dismounted and re-erected, and adjusted between such measurements.—Ed. *E.*]

* These life tests are given in another report.

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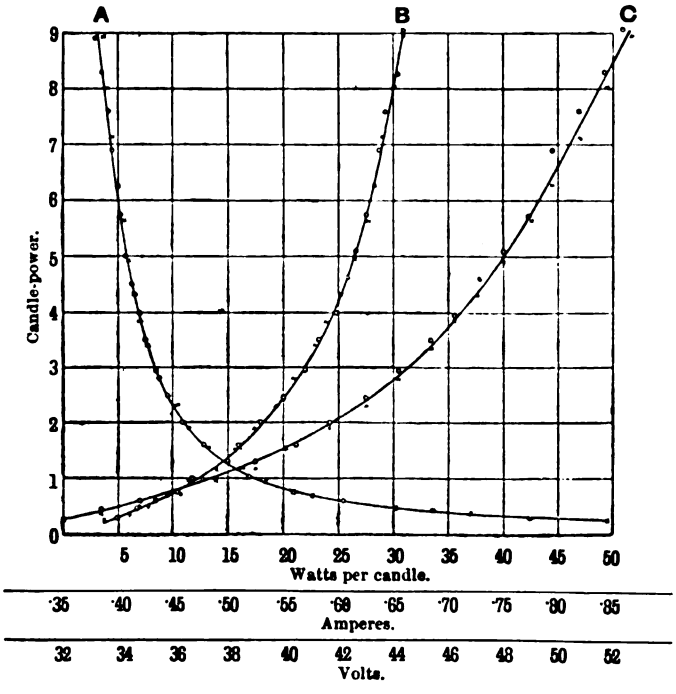

FIG. 1.—Lamps Nos. 200 and 201. Edison-Swan. Nominal volts, 50. Candle-power, 8. Resistance, cold, 162·3 and 158·3. Curves showing relation between candle-power and volts, amperes, and watts per candle. The crosses represent the observations relating to lamp No. 200 and the circles to lamp No. 201.

A Watts to candle-power. B Current to candle-power.
C Volts to candle-power.

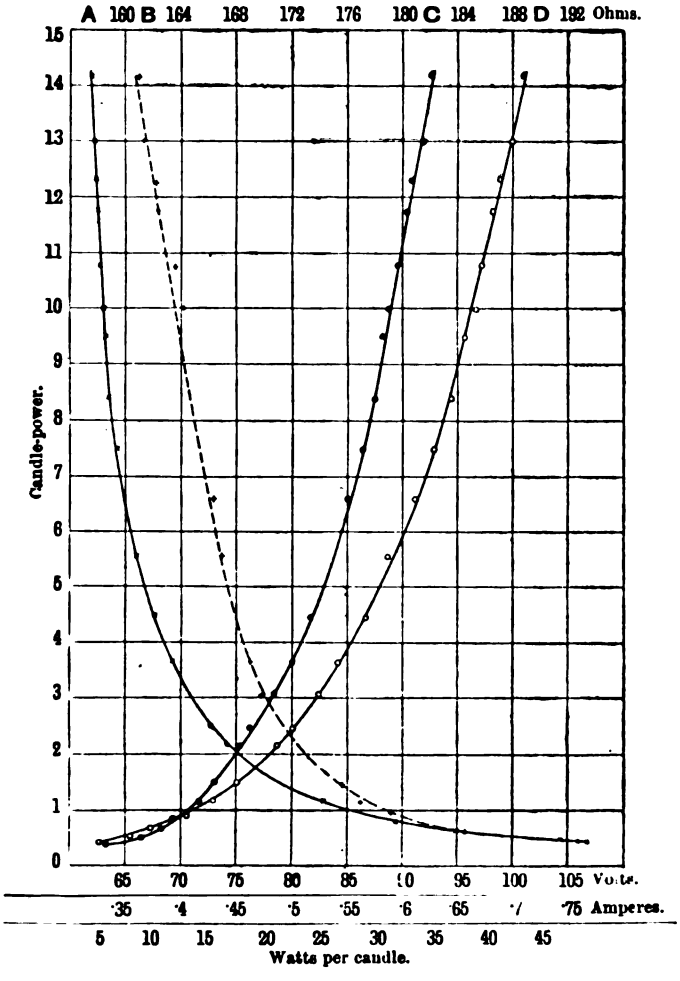

FIG. 2.—Lamp 202. Nominal volts, 100. Candle-power, 16. Resistance, cold, 327·1. Curves showing relation between candle-power and volts, amperes, resistance and watts per candle.

A Watts and candle-power. C Current.
B Resistance. D Volts.

Harvey and Peak box. Ammeter, No. 564. Resistance of lamp when cold, 311·7. Lloyd, Wicks and Turner reading.

(Twenty-two observations follow. The results are given in Fig. 3.)

Variation of candle-power with the angle which the plane of the loop makes with the plane of the paraffin blocks. Volts, 100. Ampere, 0·605.

Angle	0	22·5°	45°	67·5°	90°	End on
Mean photr. rdgs.	50·04	50·59	49·74	52·06	52·36	58·32
Candle-power	17·6	17·2	17·9	16·3	16	11·75
Watts per cand..	3·438	3·518	3·38	3·627	3·783	5·14

Photometer Error.—The mean of the three readings when marked side is to the left is subtracted from mean of the three readings when marked side is to the right, for each observer,

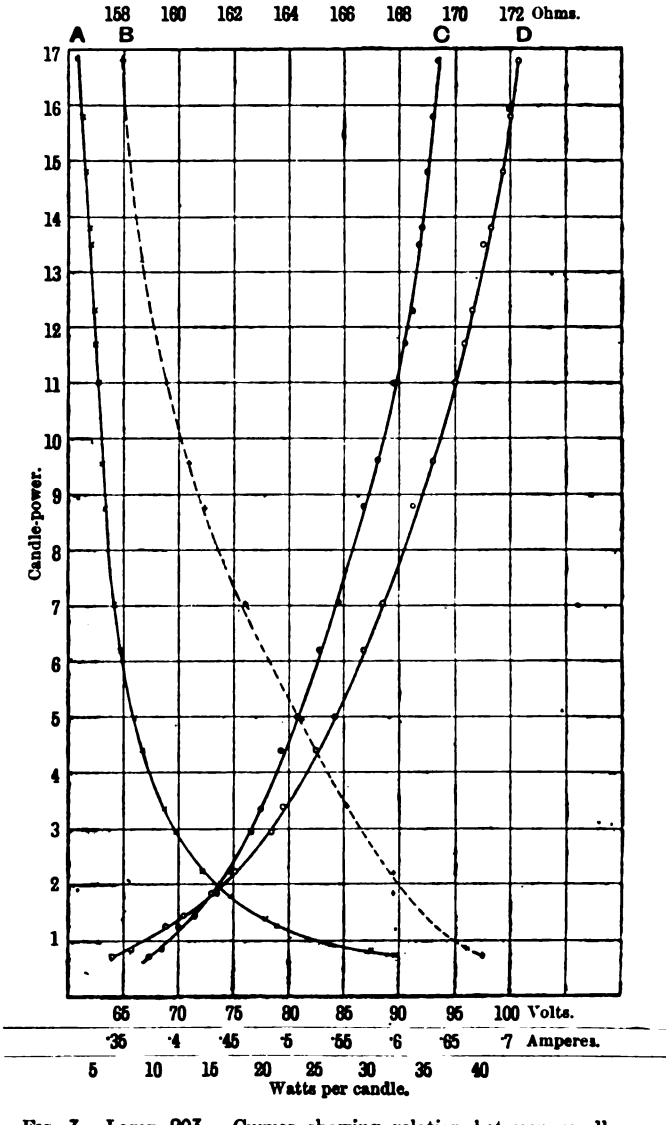

FIG. 3.—Lamp 203. Curves showing relation between candle-power and volts, amperes, resistance, and watts per candle.

A Watts and candle-power. C Current.
B Resistance. D Volts.

and half this is a measure of the error due to the blocks being unsymmetrical. And as a final approximation the mean difference from mean is taken :—

Diff. from mean. Wicks.	Diff. from mean. Lloyd.	Diff. from mean. Turner.	Mean reading. Wicks.	Mean reading. Lloyd.	Mean reading. Turner.	Mean of mean readings.	Mean diff. from mean.
2·53	3·7	2·8	125	118·5	121·5	121·66	3·01
1·6	1·85	2·13	119	112·4	116·3	115·92	1·86
2·07	2·85	3·3	111·4	105·3	109·5	107·1	2·74

(Nineteen similar observations follow.)

Mean, 2·4; percentage, 1·2.

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Personal Error.—

Mean photometer reading marked side to right.	Mean photometer reading marked side to left.	Turner's error. From mean for marked side to right.	Wicks's error. From mean for marked side to right.	Lloyd's error. From mean for marked side to right.	Wicks's error. From mean for marked side to left.	Turner's error. From mean for marked side to left.	Lloyd's error. From mean for marked side to left.
118·66	126·68	+0·04	+3·81	−3 86	−0·38	+2·85	−2·48
114·07	117·78	+0·13	+3·33	−3·47	+0·69	+2·82	−3·51
106·04	111·51	+0·23	+3·33	−3 57	+1·39	+1 99	−3·38
(Nineteen similar observations follow.)							
Means without signs.....		1·306	1·507	−2·772	+1·114	+2 006	−2·941
Means with signs		1·306	1·507	−2·772	+1·065	+1·989	−2·941

Mean without signs = 1·941
Mean with signs = 1·930
∴ per cent. of personal error = 0·96.

Error of Reproduction.—This is estimated as in the case of Lamp No. 3, by the method which is discussed in a previous report, viz.:—From the mean of each set of readings subtract each reading separately; the mean of these will give the degree of accuracy with which that reading can be reproduced:—

Wicks. M'rk'd side of photr. to left.	Wicks. Marked side to right.	Lloyd. Marked side to left.	Lloyd. Marked side to right.	Turner. Marked side to left.	Turner. Marked side to right.
0·043	0·086	0·066	0·33	0·2	0·31
0·26	0·26	0·22	0·2	0·22	0·2
0·13	0·28	0·33	0·046	0·066	0·22
(Nineteen similar observations follow).					
0·2309		0·1851		0·1699	

Lamp No. 204.

100 volts and 8 candle-power. Thin-loop filament. Resistance when cold, 465·4 ohms. Plane of loop broadside on. Resistance in Carpentier circuit, 13,000 in B.A. box No. 10 + 719 in Harvey and Peak box. Ayrton and Perry permanent magnet voltmeter, No. 567, used as an ammeter. (Twenty-two observations and the corresponding curves follow.)

Variation of candle-power with the angle which the plane of the loop makes with the plane of the paraffin blocks.

Angle	0	22·5°	45·0°	67·5°	90·0°	Endon
Photometer reading	58·85	59·27	58·75	61·28	60·35	70·51
Amperes	0·435	0·435	0·435	0·435	0·435	0·435
Volts.....	100	100	100	100	100	100
Candle-power	9·63	9·4	9·7	8·65	8·9	5·7
Watts	43·5	43·5	43·5	43·5	43·5	43·5
Watts per candle ..	4·51	4·62	4·49	5·02	4·89	7·12

Lamp No. 205.

Double-looped thin filament, broadside on. Nominal volts, 100 and 8 candle-power. Resistance cold, 475·1 ohms. Resistance in Carpentier galvanometer circuit 13,000 in box No. 10 + 719 in Harvey and Peak box. Ammeter, Ayrton and Perry voltmeter, No. 567. (Twenty-two observations and the corresponding curves follow.)

Variation of candle-power with the angle which the plane of the loop makes with the plane of the paraffin blocks.

Angle	0	22·5°	45°	67·5°	90°	Endon.
Photo. readings.	58·21	57·76	59·07	60·3	59·38	67·835
Amperes	0·4345	0·4345	0·4345	0·4345	0·4345	0·4345
Volts 100	100	100	100	100	100	
Candle-power ..	9·85	10	9·4	8·93	9·35	6·45
Watts	43·45	43·45	43·45	43·45	43·45	43·45
Watts per candle	4·42	4·345	4·63	4·862	4·65	6·75

Test of Jamieson's laws:—

$k = a\,V^6$
$k = b\,A^6$ } at normal voltage.

k being the candle-power, V the potential difference, and A the current.

Lamp 200.

$k = a\,V^m$.		$k = b\,A^n$.	
V = 51	$m = 7·25$	V = 51	$n = 6·8$
V = 48	$m = 6·8$	V = 48	$n = 6·67$
V = 42	$m = 6·7$	V = 42	$n = 7·3$
V = 37	$m = 6·3$	V = 37	$n = 7·4$

Lamp 201.

$k = a\,V^m$.		$k = b\,A^n$.	
V = 51	$m = 6·56$	V = 51	$n = 6\,9$
V = 48	$m = 6·56$	V = 48	$n = 6·8$
V = 42	$m = 7·1$	V = 42	$n = 6·7$
V = 35	$m = 6·6$	V = 35	$n = 6·2$

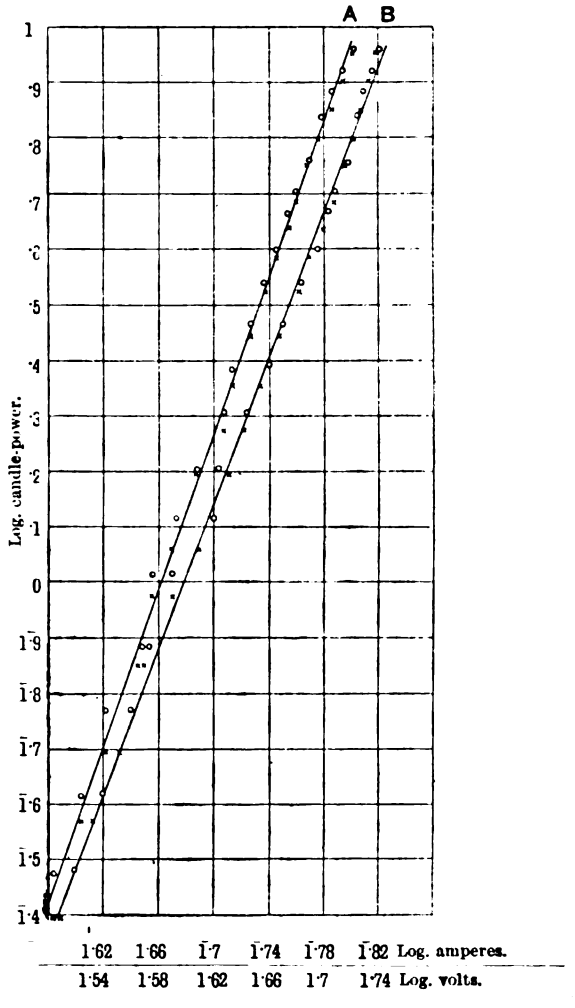

Fig. 4.—Lamps 200 and 201. Curves showing relation between the logarithms of candle-power and the logarithms of volts and of amperes. The crosses represent observations relating to Lamp No. 200, and the circles to Lamp No. 201.

A Logarithms of volts. **B** Logarithms of amperes.

Lamp 202.

$k = a\,V^m$.		$k = b\,A^n$.	
V = 99	$m = 7·56$	V = 99	$n = 6·2$
V = 93	$m = 7·4$	V = 93	$n = 6·6$
V = 84	$m = 7·6$	V = 84	$n = 6·4$
V = 80	$m = 8$	V = 80	$n = 6$
V = 72	$m = 7·5$	V = 72	$n = 6$
V = 65	$m = 7\,1$	V = 65	$n = 6·4$

Lamp 203.

$k = a\,V^m$.		$k = b\,A^n$.	
V = 99	$m = 7·1$	V = 99	$n = 5·5$
V = 93	$m - 6\,85$	V = 93	$n = 4·95$
V = 84	$m = 6·65$	V = 80	$n = 5·4$
V = 80	$m = 6·9$	V = 65	$n = 5·9$
V = 72	$m = 6·9$		
V = 65	$m = 7·1$		

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Lamp 204.

$k=a$ V^m.		$k=b$ A^n.	
V = 100	$m=6{\cdot}4$	V = 100	$n=6{\cdot}3$
V = 95	$m=7$	V = 95	$n=6{\cdot}8$
V = 90	$m=6{\cdot}7$	V = 90	$n=6{\cdot}2$
V = 85	$m=7{\cdot}3$	V = 85	$n=6{\cdot}2$
V = 75	$m=7{\cdot}8$	V = 75	$n=6{\cdot}9$
V = 70	$m=8$	V = 70	$n=7{\cdot}2$

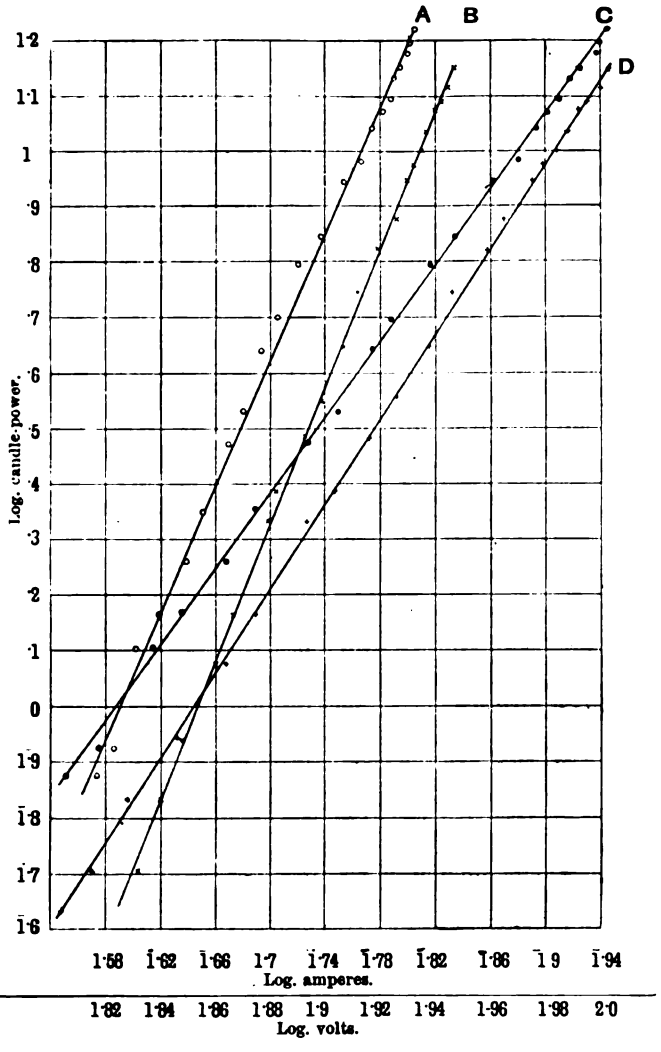

Fig. 5.—Lamps 202 and 203. Curves showing relation between the logarithms of candle-power and the logarithms of volts and of amperes.

A Logarithms of amperes, Lamp 203.
B " " " 202.
C " volts " 203.
D " " " 202.

Lamp 205.

$k=a$ V^m.		$k=b$ A^n.	
V = 100	$m=6{\cdot}6$	V = 100	$n=6\ 3$
V = 95	$m=6{\cdot}9$	V = 95	$n=5{\cdot}8$
V = 90	$m=7$	V = 90	$n=6{\cdot}8$
V = 85	$m=7{\cdot}4$	V = 72	$n=5$
V = 75	$m=7{\cdot}2$		
V = 70	$m=6{\cdot}8$		

Civil List Pensions.—The following are amongst the names in the Civil List Pensions granted by the Government last year:—Mrs. Caroline Emma Carpenter, £100, in consideration of the services rendered by her late husband, Dr. Philip Herbert Carpenter, F.R.S., to science and of the sad circumstances in which she has been left by his death; and Dr. George Gore, F.R.S., £150, in consideration of his services to chemical and physical science.

THE LUNDELL MOTOR.

A curious application of electrical energy is common enough in America, but is not likely, from climatic and other reasons, to be largely adopted in this country. We refer to the use of small motors for driving fans. Where punkahs or their equivalents are absolutely necessary such contrivances are undoubtedly useful; but we would rather suffer a good deal than add the whirr of a fan and the buzzing of a "desk motor" to the clatter of Salisbury-court and the roar of Fleet-street. It

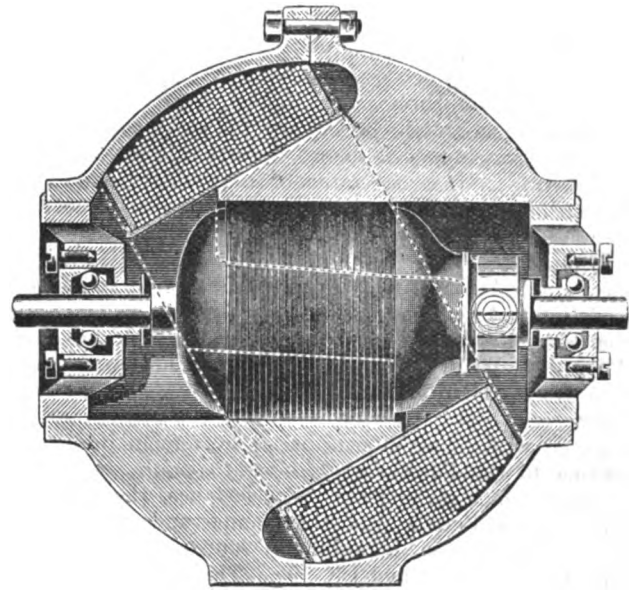

Fig. 1.—Lundell Iron-clad Fan Motor.

might be said, as was hinted by an American visitor to the City and South London Railway, that our air is not worth stirring. Be that as it may, the latest device for cooling the American brow has been brought out by the Interior Conduit and Insulation Company of New York. The magnetic leakage of small motors is said by this company to be very serious. Though at first sight the reason for this is not very evident, it is doubtless due to the fact that the cleavance between armature and pole pieces is by no means proportional to the other dimensions of a dynamo or motor, and is indeed almost a constant quantity.

The ironclad principle which, as has been pointed out more than once in *Industries*, is very much overrated, has been adopted, and a very ingenious arrangement of pole pieces and field magnets has resulted (Fig. 1). The armature (Fig. 2) is called a "Pacinotti drum," but seems to be rather a perforated armature with slots for facility in winding, like the armature of the magneto used with the Evershed ohmmeter. In the description of this motor which appears in the American

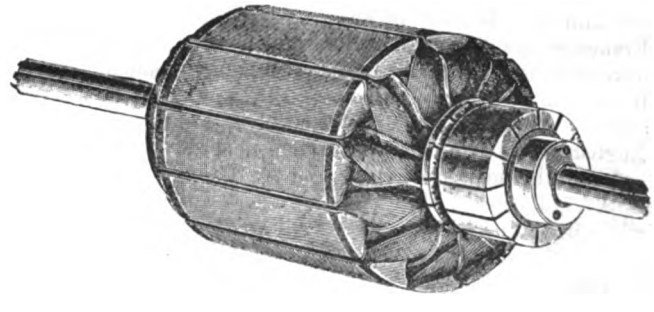

Fig. 2.—Armature of Lundell Fan Motor.

journals, it is said that the motor is sparkless, and the point of commutation remains fixed within the limit of load, and at reversal of rotation. The brushes are small carbon pencils. The $\frac{1}{12}$-H.P. size is fitted with ball bearings, and runs at a maximum of 1,800 revolutions per minute. On a 100-volt circuit they run at 900 to 1,150. Motors giving $\frac{1}{6}$-H.P. are also made.

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THE PROPOSED FRENCH-AZORES (HAYTI) CABLE.

[COMMUNICATED.]

It will be in the recollection of those of our readers who are interested in submarine cable matters that the Portuguese Government granted a concession to the Société Française des Télégraphes Sous-Marins for the laying of a cable to the Azores. The matter is now about to be submitted to the French Chambers in the form of a project for establishing submarine communication from Brest to Lisbon, thence to the Azores, and on to the Island of Hayti. The cable, which is to be constructed in French factories, will be laid and worked by the Société Française, which possesses already 3,754 miles of cable connecting two or three of the foreign West Indian Islands with French and Dutch Guyana and the north coast of Brazil, and which Company, as is shown hereafter, is already in sore financial straits. In consideration of connecting the new system with that of the Antilles a subsidy or guarantee of traffic by the French Government of £92,000 per annum for 25 years is asked, plus £10,000 for maintenance, which latter is absolutely inadequate. Amongst the advantages expected to accrue to French interests in consideration of this very large payment is the creation of more rapid communication with the Antilles and South America. These countries are at present served by the North Atlantic lines, of which only one, the Pouyer-Quertier, is French. Beyond New York the communication is carried on with many intermediaries by foreign lines. This, according to the Paris *La Politique Coloniale*, explains the high tariffs which are in force. For instance, the charge per word between France and Guadaloupe and Martinique is 11f. 25c. and 15f. 65c., according to route; while for Guyana the rates are 13f. 35c. and 15f. 55c. The authors of the project claim that the creation of a direct and economical route will attract a considerable part of the traffic, and will, in addition, be advantageous to the French colonies concerned. Our French contemporary congratulates the Minister of Commerce upon his solicitude for the interests of the colonies, but points out that it would be more useful to connect with the mother country those dependencies which do not possess telegraphic communication than merely to reduce tariffs by laying competing lines.

Thus far our information has been obtained from French sources, and we may now proceed to consider what prospect there is for a cable which connects Brest with Lisbon, the Azores, and Hayti. Some source of revenue will undoubtedly be the traffic between Brest and Lisbon. The traffic between France and the Azores cannot be important, as there is hardly any trade. With the colonies of Martinique and Guadeloupe there are only a few messages a day; while those from Hayti by the new line will not amount to much. And there seems to be little doubt that the French Government will be called upon for the greater part of the amount of traffic guaranteed, as is the case with Portugal, which, under the guarantee of £41,900 for the cables on the West Coast of Africa, has to pay £27,000 per annum. By way of showing to what extent the Société Française des Télégraphes Sous-Marins are laying cables which have not the remotest prospect of securing an adequate revenue from traffic for many years to come, it will be of interest to analyse its last balance sheet, which, arranged according to English methods of account, stands as shown in next column.

It will be seen that the profit on paper for 1891 is shown as £3,711, but nothing has been set aside for depreciation, while in 1890 £4,575 was reserved on this account, nor has any part of the discount on the issue of debentures been charged to revenue. Further, only six months' interest on the debentures enters into this account, and as the debentures are repayable by annual drawings, the following amounts should have appeared:—

Depreciation (30 years' life)	£8,800
Sinking fund (debentures redeemable in 30 years)	2,137
One-thirtieth of the cost of issuing debentures	900
Total	£11,837

Thus turning the profits of £3,711 into a loss of £8,126. Again, during the year a sum of £20,167 was received from the Société Générale des Téléphones in respect of interest, guaranteed during construction, which sum the Société Française propose to pay to their shareholders in two halves. Apparently, however, the construction of the lines being now completed, the guarantee ceased with the year 1891, and the Company will be left to face a certain loss. The traffic is not likely to increase, while on the other hand interest on debentures will be £7,100 more, and the working expenses will be increased because some of their stations were not open during the whole of 1891.

All experience shows it to be hopeless to argue with the advocates of Protection; but if the French Chamber likes to make the whole community responsible to the extent of £102,000 annually for 25 years in the interest of the few artisans in the French cable factories, and cable promoters, it can only be regarded as an instance of Protection run wild. In fact, if all the minor industries in France were to be "protected" in like manner, even the enormous resources of that country would not bear the strain imposed upon them.

The truth is that unless the Government do something for the Société Française, which is hopelessly insolvent, that Company will have to be wound up, and it is evident that the guarantee of traffic and working expenses (which are to be deducted to the extent of £10,000 a year from the receipts for traffic before the guarantee is calculated) to the enormous extent of £102,000 per annum is calculated to provide a small dividend on the capital already expended, as the Company's existing lines must necessarily, unless the traffic grows, work at a loss of over £15,000 per annum.

A very liberal estimate of the cost of laying the projected sections, furnishing stations, &c., is £1,000,000; but the *exposé des motifs* submitted to the Chamber calculates the price at

Expenditure.	1891.	*Revenue.*	1891.
General expenses	£4,820	Message receipts	£28,582
Working expenses at stations	16,757	Subsidies and guarantees of traffic	6,713
Interest and loss on exchange	—	Interest	1,138
Depreciation	—		
Written off preliminary expenses and office furniture	2,622		
Directors	1,058		
Stamps on shares and bonds	365		
Interest on debentures, half-year, 5 per cent.	7,100		
	£32,722		
Balance down	3,711		
	£36,433		£36,433
Proposed dividend for 1891	20,166	Balance in 1891	3,711
Balance carried forward to next account	7,692	Balance from 1890	3,980
		Guaranteed interest received from Société Générale des Téléphones on the shares	20,167
	£27,858		£27,858

BALANCE SHEET.

Dr.	1891.	Cr.	1891.
Capital—Shares, £440,000 / Bonds, £284,000	£724,000	Cost of cables, &c.	£717,086
Depreciation	17,800	Cash at bankers	11,462
Reserve legale	758	Bills receivable	2,922
Sundry creditors	9,803	Sundry debtors	7,338
Bills payable	1,120	Subsidies and guarantees owing	7,534
Special reserves (*see* below*)	15,702	Caution money deposited with Governments	10,271
Unclaimed interest	512	Repairs account	347
Proposed dividend	20,166	Taxes to be recovered	1,401
Balance to next account	7,692	Cost of issuing bonds	27,194
		Preliminary expenses £10,961	
		Less written off 4,578	6,383
		"Comptes de Participations" (?)	5,625
	£797,553		£797,553

* The item "special reserves" of £15,702 is misleading—it was not created out of revenue, but out of capital

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£1,320,000. It would be very interesting to know what is to become of the odd £320,000. Do the French Government desire to "protect" the promoters or the Société Générale des Téléphones, the manufacturing company, by making them a present of that sum, the French taxpayer having to foot the bill by paying interest and amortisation upon it for 25 years?

Assuming the maintenance (which is to be to the extent of £10,000, a first charge on the receipts) at £15,000, amortisation fund for debentures £27,400, and expenses of repairs at £4 per mile per annum, we get the following result:—

Revenue.		*Expenses.*	
Traffic guaranteed	£92,000	Working expenses £15,000	
Maintenance	10,000	Amortisation Fund 27,400	
		Repairs 17,600	
			£60,000
		Net profit of new lines ..	42,000
	£102,000		£102,000

This profit shows a dividend of 3 per cent. on £1,320,000, or deducting the loss of £15,000 per annum on the old lines, 1½ per cent. on the whole share capital of the Compagnie Française, which will be £1,760,000, assuming the new capital to be entirely in shares, when the new sections are completed.

Again, it will probably be found necessary to raise some considerable part of the £1,320,000 (say half-a-million) in debentures, in which case interest at 5 per cent. would be £25,000, leaving only £2,000 to pay dividends on £1,260,000,

It has apparently been overlooked that by guaranteeing traffic on this new line between France and South America, the French Government will actually be subsidising a line which will be in competition with its own cable between the Canary Islands and Senegal.

The last advices show that the Budget Committee has reported against the project, which was not submitted to the Chamber before it rose on the 13th inst. Doubtless, if the matter ever comes before the Deputies they will see this proposal in its true light.

LONDON CHAMBER OF COMMERCE.

THE ELECTRICAL TRADE SECTION.

A meeting of the Electrical Trade Section of the London Chamber of Commerce was held at the offices, Botolph House, Eastcheap, on the 8th inst., under the presidency of Major Flood Page.

The SECRETARY (Mr. Kenric B. Murray) having read the minutes of the last meeting,

The CHAIRMAN stated that since the last meeting of the Section they had gone one step in advance in regard to the important question of electrical traction, and a day had been arranged when they would meet gentlemen on the opposite sides of the matter, with a view to seeing whether they could not save the expenditure of £100,000 in litigation. He dared not say that they were hopeful, but nevertheless they had arranged a meeting at which the National Telephone Company, on the one side, and the traction interests on the other, would be represented; and they were going to see whether it was possible to agree to some *modus vivendi*, and something should be done to avoid litigation, which, as far as they could see, would be very serious. They were told on the one hand that Leeds would settle nothing, and on the other hand that it would settle everything; and if, through the Chamber, they could come to some arrangement between the two parties, they would have accomplished something very great for electrical industry. He was going to ask the permission of the meeting to take the agenda out of its order, as Mr. Preece was compelled to go Wales, and that gentleman wanted to tell them what had been done with reference to the Chicago Exhibition. A committee had been appointed, and they had had a meeting, and he need only say that the result of that meeting was that they had determined to call the present meeting in order that Mr. Preece might inform them of how matters stood.

Mr PREECE said that up to the present time the prospects of a successful electrical exhibit at Chicago were very remote, while, on the other hand, the display of other industries was going to be a very great success. The most magnificent display ever despatched from this country to any Exhibition was going to be sent to Chicago. There were over 1,500 exhibitors, and the space allotted to them had had to be reduced. In the case of the Electrical Section, on the other hand, out of 20,000 square feet which had been allotted to it, only 5,000ft. had been taken up. There were, however going to be some very good exhibits. He had a list of those who had applied for space, as follows:—For electric batteries the Epstein Company had applied for 210ft.; for machines and appliances for producing electrical currents by mechanical power, the Electric Construction Company, of Wolverhampton, had applied for 1,088ft.; Messrs. Parsons and Co., Heaton Works, Newcastle-on-Tyne, had applied for 200ft.; Mr. Robert Ewing was going to give an exhibit of conduits of electric cables; Messrs. Ferranti had applied for 450ft., and were going to have a very large show of alternating-current motors; Mr. Lorrain, of the Strand, had applied for 110ft. to show an electric system of ventilation, clocks, &c.; there would be a very large and fine display of the General Electric Company, of Queen Victoria-street, which would be under the careful attention of their friend, Mr. Binswanger; Elmore's American and Canadian Patent Copper Depositing Company were going to show in actual operation a large exhibition of electro-deposited copper; the London Metallurgical Company had applied for 1,600ft., and were going to give an exhibition of silver plating; the Post Office was going to transfer almost bodily the exhibit which it had at the Crystal Palace; Messrs. Anders and Kottgen, Jeffery's-square, would have an exhibition of telegraphs, electric signals, and phonographs; the Phonopore Syndicate, of London-wall, would have an exhibit of phonopore telegraph apparatus; and in regard to their last section, the telephone and its appliances and phonographs, there would be exhibits by the Collier Audible Telephone Company, and the Homacoustic Speaking Tube Company. That was the official list of applications up to the present time, and he thought they would agree with him that it did not adequately represent the British electrical industry. His object in coming there that day was to ask for their assistance to get something more—to get some typical display of the modes of fitting up houses in the manner which was peculiar to English practice. His notion was that they should get together, if they possibly could, a syndicate, which would put up a suite of rooms, furnished by English furniture makers, decorated by English decorators, and fitted up by electric light engineers with all the latest and best appliances. If ten members could be induced to subscribe £200 each to show their own particular exhibits, the Royal Commission would come forward and take charge of the exhibit, and find funds to assist in carrying it out. That was the only suggestion he had to make. He might add that since their meeting they had received a circular dealing with the department of electricity at Chicago, which was asking English contractors to tender for the lighting of portions of the buildings, of which a certain part had been set aside for European houses.

Mr. EMILE GARCKE thought they were very much indebted to Mr. Preece for attending that meeting and giving them the information which he had done. He thought the suggestion which Mr. Preece had thrown out with a view to a combination on the part of several of the firms who had specialities was a very good one, and he would venture to suggest to the Committee for its consideration whether a circular could not be issued to the Section with a view of Mr. Preece's suggestion being adopted. He thought there were a number of firms in the country to whom the suggestion would be acceptable. On the other hand, there might be some difficulty as to firms representing heavy electrical engines, with regard to the difficulty they had of importing their machinery into America. He almost thought it would be better if Mr. Preece could suggest a smaller sum.

Mr. PREECE said that he had only mentioned £200 as an illustration.

Mr. BINSWANGER observed that in regard to drafting the circular to which reference had been made, the main question which presented itself to his mind should not be lost sight of, and should be mentioned in the circular, namely, that the Electrical Exhibition was not one which would be of use to them mainly for their trade with the United States, but with foreign countries. He believed the Chicago Exhibition would be the meeting place of a great many foreigners from South America, Canada, China, and the East, who would go there to see what was being done in connection with electricity. Most of those who went there would be interested in electrical matters, and from this point of view he believed that the Chicago Exhibition would be of the utmost importance to English electrical manufacturers. They were in the present moment in a peculiar state. Electrical engineering had passed the stage of experiment, and their resources for manufacturing were very great. They were all looking out for foreign markets in order to supply them, but foreign makers would be doing the same thing; and the race for these markets would be extremely keen. From this point of view the Chicago Exhibition would be of great importance. He did not speak at random, but from actual experience. For the last two or three years he had, through agencies, established a certain connection in the countries he had mentioned—especially in Canada, Mexico, Japan, and China; and he might inform the Chamber that he had received notices from almost every customer in those countries of their intention to visit the Chicago Exhibition. If, therefore, he were to abstain from exhibiting at Chicago, he

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would very likely lose what he had already gained, and other people might come in where he had already established a trade. This seemed to him to be a very important point, and he was sure that English manufacturers could show up well in regard to either heavy or light engineering fittings, and could produce articles which would compare well with others. In England, thanks to the efforts of scientific men, fire insurance companies' inspectors, and consulting engineers, and an immense capital invested in electrical enterprise, the industry had been established on a sound and independent basis compared with what was seen in other countries. He believed that the industry would be helped by a comprehensive display of electrical goods at Chicago. As Mr. Preece had said, his (the speaker's) Company had decided to have an exhibit, but he did not believe that it would do them much good individually. He believed it would be better for his Company and other individual firms exhibiting if their *confrères* and other large manufacturers would exhibit comprehensively and together as one section.

The CHAIRMAN said he desired to ask Mr. Preece one question. The Chamber at one time ascertained that English exhibitors might put their English prices on all their goods as well as the prices at which they would be able to sell them at in America. A rumour, however, had reached him that this right had been countermanded, it being feared that if the two prices were shown at the same time the Americans would discover how much they had to pay through their protective system. He had heard, therefore, that the price at which the goods could be sold in England was not to be hown.

Mr. PREECE, in reply, stated that the executive of the Chicago Exhibition distinctly conceded to them the right to display on their goods the prices of the articles in England and America. A rumour got into the Press that this right was to be taken away. Sir Henry Wood thereupon went out to the United States with an *ultimatum* implying that if it were true that the concession mentioned was to be departed from, they would probably on this side take very strong measures indeed; but on the very day that Sir Henry Wood arrived in America, he telegraphed back saying that everything had been arranged most satisfactorily. The right in question, therefore, remained with them.

The SECRETARY, in reply to Mr. ERSKINE, said it was quite possible that if the Electrical Section decided to make a commencement towards carrying out Mr. Preece's suggestion, furniture, carpet and curtain manufacturers might be induced to take part in the Exhibition in connection with the suggestion that had been made.

Mr. MARSHALL (Gainsborough) said he thought it should be known that the steam-engine makers there had resolved to keep away from the Exhibition; and in connection with agricultural machinery, it had been unanimously decided that it would be disadvantageous to exhibit at Chicago.

The CHAIRMAN, after alluding to Mr. Garcke's suggestion as to the issue of a circular to the members of the Section, said that if sufficient members said they would exhibit, Mr. Murray could get the textile or furniture manufacturers to have a meeting to see what could be done in the direction which had been indicated. If this were regarded as a practical suggestion, the Chicago Committee would draft a circular and send it out. He thought it only right to say that some of the companies were in a difficulty. The companies who really supplied American patents in this country could hardly exhibit in Chicago.

It was eventually decided to issue the circular in question.

The CHAIRMAN then observed that what he was about to say was practically in the nature of a report of the Committee appointed at the annual meeting to deal with what seemed a very difficult question—namely, the London County Council rules with regard to overhead wires. They had had the advantage at the Committee of hearing the full evidence of the National Telephone Company, the New Telephone Company, and the Exchange Telegraph Company—in fact, of all interested in overhead wires, apart from wires for the purpose of electric lighting. When they entered on their task they felt that the rules in question were most restrictive of trade, and that they would really be seriously detrimental to the welfare of the electrical industry. They felt this to such an extent that after several meetings, at which they had had to work pretty hard, they prepared a petition to the Board of Trade. When he told the Section thatthe number of the bye-laws was 22 and that they objected to all of them except five, those present would see that the Committee had traversed the case of the London County Council pretty completely. He would like to state that the officials of the Chamber pushed forward the petition extremely well under great pressure. The Council of the Chamber were kind enough to give the Committee their full support, and the result was that the petition went on. A meeting of the officials of the Board of Trade was held with the representatives of these companies and of the London County Council. The result was that certain concessions were granted, but they did not go far enough. With the greatest possible courtesy, the President of the Board of Trade had allowed the Chamber to appear even after the inquiry had been held. Sir Vincent Barrington introduced the deputation on behalf of the Council, but under the circumstances it was a very small deputation. A good hearing was given to them, and the result had been to show, first, the willingness of the Board of Trade to listen to any sensible suggestion, and, secondly, the influence of the Chamber of Commerce; for, of the 22 rules to which he had referred, only one was unaltered. Upon this point he was bound to ask them not yet to give way. He would mention one or two instances showing the nature of the alterations which they had succeeded in obtaining. The Act under which the bye-laws were made was passed in 1891. This gave the County Council power to make bye-laws for the purpose of identification and regulation of the wires. The County Council demanded that before any wire was placed they should have a fortnight's notice. The companies naturally said that that was impossible; and eventually it was settled, thanks to the good sense of the Board of Trade, that instead of 14 days' notice beforehand, notice was to be given within one month after the wire had been put up. There were other very vexatious restrictions, and the view which he took, after meeting the Board of Trade officials, was that if the latter could be convinced that anything was really restrictive of trade, they were most willing to try and alter it. They had this difficulty: the Local Authorities were very powerful bodies, with whom they themselves could not compete with influence. Another rule—not very wise—was that the London County Council restricted themselves as to the length of span. It had been agreed that the companies should not have a greater length of span than 115 yards, but the London County Council had prohibited themselves from giving permission for more than 140 yards. That restriction had, however, been taken away. Another absurd thing was this: Some of the companies now had 70 and sometimes 140 wires on one pole, but they were to be restricted to 20. That had also been done away with. All that had been asked of them now was that whoever owned the poles should be responsible for the safety of the wires. There was a matter of very great importance in connection with this subject. The telephone industry had become a question of the greatest importance, and it must increase in importance, as they would gather when they bore in mind that during last year 160 millions of telephone messages were sent in this country, at a cost of little more than ½d. each; whereas only 66 millions of telegraph messages were sent, at a cost of about 7½d. The progress of the telephone had been so wonderful that they could understand the Postmaster-General calling out that his business had been damaged by it. The Board of Trade had met the telephone companies on every point except one; and he wanted to urge the Section to authorise the Committee to see if they could do something more in regard to this one point. They insisted still that the owners of the wire should be compelled to give permission to the Local Authority or the County Council, by themselves, their agents, or servants, at all reasonable times, to go on to the premises of any one to examine the wires and poles—the premises of anyone having given permission for a wayleave. He told Sir Courtenay Boyle that this was most restrictive to trade. A company might go and say to a man, "I want a wayleave here." The reply might be, "I shall be very glad to let you have it." Then the Company would say, "I am bound to tell you that at all reasonable hours the County Council inspector or servant might come on to your premises to inspect the wires." Upon that the Company would receive a refusal. While they fully recognised the great kindness and courtesy of the Board of Trade and the concessions they had already obtained, he asked them to authorise the Committee to take what steps they might think fit, with a view of getting some amelioration in the regulation referred to, so that the companies might endeavour to obtain permission for an inspection of the premises over which wayleaves had been erected; but that they should not be compelled to get this permission. The only reason for the bye-law was on the ground of public safety. They were all probably aware that before a Parliamentary committee two or three years ago it was established that out of 700,000 accidents in London only two could in any way be traced to telephone wires, which were then under no regulations. With respect, therefore, to the public safety, there could be no necessity for this upsetting of the theory of an Englishman's house being his castle by allowing the public authorities, "at any reasonable time," to go over his premises. He, therefore, asked them to let their committee still endeavour to work so as to get the alteration in question assented to.

Mr. BENNETT said he desired on behalf of his own company—and he believed he might also say on behalf of the National Telephone Company—to express their gratitude to Major Flood Page and the committee for the great trouble which they had taken. He thought that the telephone companies were now contented—since there must be bye-laws—with the existing bye-laws with the one exception that had been referred to. With the knowledge he had of telephone companies' business, he was sure that this bye-law would prove an insuperable obstacle to their business in many ways. It was very difficult in existing circumstances to obtain wayleaves, and

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it was often utterly impossible to overcome the scruples of some persons about them. When the bye-law in question was added, he was sure that the wayleaves which they could at present obtain would be greatly reduced in number. If the committee considered it possible to do anything further, he thought that they ought to agree to the effort being made.

General WEBBER considered that there would be little difficulty in introducing into the wayleave agreement a clause which would permit an official of the Local Authority, in the interests of public and private safety, to inspect the attachment, accompanied by an officer of the company. He did not think they need have much to fear if they could agree with the Board of Trade that in future a carefully worded clause should be introduced into the wayleave agreement. With such a clause carefully worded he did not consider that wayleaves would be refused. As regarded the wayleaves which had already been obtained, the question was much more difficult. In such cases the Local Authority were, he thought, bound to show how the permission to inspect was to be obtained; and they had not shown how they were going to get over the difficulty.

The CHAIRMAN stated that their strongest point was, perhaps, one that he had not mentioned—that in the Bill which was eventually turned into the Act which gave the London County Council the bye-laws, they sought to obtain this power, but Parliament threw it out.

Mr. GARCKE thought that a clause could be introduced and made to appear as if it were in the interest of the householder, and that was a strong point in its favour if nothing better could be done; but if, as he understood, it was believed that there was some reasonable hope of getting what was wanted, it would not be advisable to put in the clause suggested by General Webber.

General WEBBER agreed that it would be better, of course, to have nothing said in the agreement about the matter.

Eventually it was decided to give the Committee the authority desired by them.

The CHAIRMAN stated that the next matter on the agenda was with reference to the action that had been taken by the Special Electrical Traction Committee. Those who were present were acquainted with all that the Committee knew, having heard read the proceedings of that Committee by way of report. They looked forward to the meeting to which he had referred—which was to be held in the following week—with very great interest, and if the arbitration of the Chamber could be used effectively, it would be, as he had already said, greatly beneficial to the industry. It was a very difficult question that they had to deal with, and one in connection with which the lawsuit that was now in progress in Leeds would only be the first of a large number. They had not yet approached the Post Office at all. They were only dealing with the companies that were now in dispute—the parties to the Leeds trial—practically, the National Telephone Company and the traction industry represented by the Leeds Tramway Company.

Mr. SINCLAIR said he believed it would be found that in most of the Bills that had been issued there was a saving clause to the Postmaster-General.

The CHAIRMAN afterwards stated that a member of the Section had given notice of his intention to draw the attention of the Committee to three matters—the standardising of machinery, uniformity of prices, and foreign competition. The member had given several reasons why he regarded these three points as of very great importance, but he had been called away to Manchester, and could not possibly be present that day. He thought they would all agree that these were matters which might be very well considered. About three years ago they tried the standardising of machinery, but they utterly failed to arrive at any conclusion, but that did not prove that the same result would follow now. Would the meeting approve the formation of a committee to deal with these three subjects?

Mr. GARCKE said he thought they ought first to hear what the member who had put them on the agenda had to say about them. They were all large and important questions, but they could be treated from so many points of view that he thought the Committee ought to have some practical instructions in regard to them.

It was ultimately decided to postpone the consideration of the matters, and it was subsequently decided to adjourn until October, the Section only to be called together in the interim in the event of there being anything important to communicate, the Committee holding their meetings in due course.

The CHAIRMAN, in reply to General WEBBER, said he thought they all felt that the question of electrical traction was very important, and when they met in the following week they would see what could be done to arrive at a settlement. With respect to the Leeds trial, a notion was abroad that litigation had gone so far that it was almost impossible to prevent its continuing; but on a review of all the circumstances it was felt that a meeting should be held beforehand, and that there might be a possibility of doing something.

The proceedings then terminated.

CORRESPONDENCE.

CARBON BRUSHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our experience in connection with train lighting dynamos on the Midland Railway may be of some value in this matter.

The dynamos are compensated for variation of speed by the automatic inverse variation of induction through the armature. The current from the dynamo varies from 60 amperes, for a light train, to 110 or 120 amperes for a heavy train. Under all these changing conditions, the lead of the brushes remains the same, merely reversing with reversal of direction of rotation. As would be presumed, the sparking with ordinary copper brushes was sometimes very considerable. Owing to the heavy jolting, the brushes have to press very heavily upon the commutator, and having to work on a commutator running in either direction, they must be radial, or nearly so. The only copper brushes that would behave well at all were gauze brushes, and, as an Irishman would add, they behaved abominably.

When we were at our wits' end, over two years ago, I tried some carbon brushes on a machine that was sparking badly; and it is merely the truth to say that since then the trouble has absolutely disappeared. All the commutators were turned up—(a true surface is necessary for carbon), and carbon brushes replaced the copper gauze. We never have to touch these commutators now. Doubtless, it would be preferable to have a considerably larger segment area for carbon brushes, but we had to do what we could with that which we had got.

They get rather hot with 100 amperes on for a long run, but the friction alone is answerable for 50 per cent. of the heating.

The only carbon in our stores on the morning I decided to try it was some hard gas carbon used for battery plates. Although we have tried several special makes since, nothing has suited the work nearly so well as this hard carbon—most of the other kinds wearing away too soon. There are two pairs of brushes on each machine, and the carbon is of the same size as the original gauze, viz., about $1\frac{1}{4}$in. by $\frac{1}{4}$in., and projects only $\frac{1}{4}$in. from the holder. The resistance of the contact is, I presume, the cause of their spark-annihilating property. We find it necessary to slightly lubricate the commutator.

Where a dynamo is under constant supervision and control, nothing, I venture to think, can beat gauze for brushes. But where a dynamo is subject to changes of speed, direction of rotation, induction, and current output, without supervision, carbon brushes are the only ones possible.—I am, &c.,

Midland Railway, Derby. J. SAYERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 8th a question is asked as to whether carbon brushes have been used for loads of 100 amperes. In America the great majority of dynamos for power and railway purposes use such brushes. One manufacturing company have in use considerably over one thousand dynamos, each of which has a capacity of over 120 amperes using carbon brushes, some of which machines have been in use for the past four years. The satisfaction that carbon has given has led the Thomson Houston Company to universally use carbon for all machines of 500 volts. In the bipolar type of machines two brushes are used in each holder, the area of contact being approximately $\frac{9}{16}$in. $\times$ $1\frac{7}{8}$in., the load of such machines being 120 amperes.

The largest machine using carbon brushes to the writer's knowledge has an output of 720 amperes, a cut of which is published in the *Electrical Engineer* of New York in the issue of June 29, page 655. This machine, together with a number of others, being constructed for the West End Street Railway Company of Boston for the new Power House. The quality of the carbon brush as well as the size of commutator are the principal considerations in designing such brushholders. The rise in temperature of a brush should not be greater than 100° Fahr. when running continuously on full load. However, such a rise is not often attained in practice, as the load on a power circuit is well known to be a fluctuating one. Where troubles have been met with the fault has not infrequently been found

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to be in the contact between the brushholder and brush rather than between the brush and commutator.

There are numerous carbon brushes on the market good and otherwise. An ideal brush is the Carré manufactured in Paris; the carbon is of medium texture, free from grit, very little liable to break or chip, and very uniform. A soft brush on the one hand will smut a commutator, and a too hard brush will be liable to collapse or chip. The American imitation Carré brush leaves very little to be desired, and is only inferior to the French one in point perhaps of uniformity. Tangential carbon brushes are generally not very advisable. All carbon brushes should be copper-plated to insure good contact between the holder and brush, and for this reason the deposit should be tapered from a fine deposit near the point of contact to a thick coating near the butt. A carbon brush should have at least 1½ area of a copper brush for the same load.—Yours, &c.,

J. DOUGLAS DALLAS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your remarks on the subject of carbon brushes, there seems to be no difficulty in the use of such for large currents, provided that the surface of contact between the brushes and the commutator is not less than 1 square inch for each 40 or 50 amperes. There is always a considerable heating of the commutator due to spark-suppression, since the energy which would otherwise be dissipated in the spark appears as heat at the surface of contact between brush and commutator. This heating, though injurious if excessive, does not destroy the surface of the commutator, as sparking would. There is no doubt that carbon brushes, either in the simple or the divided form, are most valuable where constant lead with variable load is necessary.—Yours, &c.,

Kensington, July 12, 1892. R. H. HOUSMAN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following particulars may be of interest to those concerned in the application of carbon brushes.

For high-tension machines, especially when there is great variation in the external load, carbon brushes are most beneficial, and, indeed, necessary; but in dynamos in which heavy currents are forced through the brushes by a low E.M.F., the sectional area of the carbons would have to be such as would render their use impracticable. Apart from the consideration of resistance, 30 amperes per square inch of rubbing surface is a good working current density.

The most noticeable feature in the working of carbon brushes is the peculiar property they possess of not only reducing the sparking, but greatly neutralising its effect on the commutator, a phenomenon which, I believe, has not yet been accounted for. If a current density of 50 amperes per square inch be given, the carbon becomes incandescent at points, but the effect on the commutator is even then trifling compared with what would have been the case if similar conditions could have been set up with copper brushes.

In many cases the sparking in low-tension machines with copper brushes can be to a great extent prevented by employing a carbon tip at the end of the brush, where the sparking occurs.

I may remark that, although a good quality of carbon is essential, the manipulation of the brushes is of just as much, or even more, importance. As a case in point, I am informed by Mr. Chamen, of Messrs. Crompton and Co. (Limited), that one of their motors was made to run for 15 months, in constant work, with only one pair of carbon brushes, and that during that period the commutator showed no signs of wear, but kept a smooth polished surface, although the conditions of working necessitated the frequent stopping and restarting of the machine.—Yours, &c., N. G. THOMPSON.

ARC LAMPS ON 50-VOLT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your extract of a forthcoming work by Messrs. Geipel and Kilgour, I observe it is stated that for working arc lamps in parallel there should be at least 60 volts available; but that 65 volts give better results, whilst 70 volts are used in some cases.

As such a statement, if allowed to pass unchallenged, may give rise to the erroneous impression that all arc lamps require at least 60 volts to give satisfactory results, I shall esteem it a favour if you will kindly give publicity to the fact that at Winchester House in Old Broad-street, there are several "Brockie-Pell" lamps, taking currents from six to 10 amperes, which have been working for some years in parallel with incandescent lamps *on a 50-volt circuit*. This pressure is kept very constant; and seeing that some of the lamps are used for illuminating the hall in the basement where companies' meetings are held daily, I think it is superfluous to say that the light leaves nothing to be desired. The arcs have in fact displaced a large number of incandescent lamps.

I may also mention that there are hundreds of the same type of lamp about the country giving the greatest satisfaction, which are working two in series on 100-volt incandescent circuits.—Yours, &c., JAMES BROCKIE.

Charlton, Kent, July 12, 1892.

TEST OF TWO 6,500-WATT WESTINGHOUSE TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the report of Dr. Hopkinson on our transformers, a copy of which has been sent to you, we have just received an intimation from Dr. Hopkinson that an error has occurred in the last paragraph but one, namely, the efficiency of the transformer at quarter load should read, "over 92 per cent.," instead of "84·7 per cent."

We should feel much obliged if you would kindly refer to this correction in your next issue.—Yours, &c.,

ARTHUR E. SCANES,
Secretary Westinghouse Electric Company.

[We are compelled to leave over an interesting letter on Electric Lighting in Switzerland.]

LEGAL INTELLIGENCE.

COURT OF APPEAL.

St. George Lane Fox v. Kensington and Knightsbridge Electric Lighting Company.

SUMMARY OF COUNSEL'S ARGUMENTS FOR DEFENDANTS.

We give below the Summaries of which both parties to the Appeal, now awaiting judgment, were permitted to make use. These Summaries are, of course, of a very disjointed character, but lose nothing by being compressed into paragraphs:—

FIRST.—*Lane Fox's Appeal.*

Defendants have now shown:—

1. Ayrton's curve breaks lamps at 110 volts.

2. 110 volts must be passed if (*a*) batteries to store; (*b*) batteries to regulate flicker; (*c*) batteries to be kept in health. Therefore some method to be adopted either to charge when lamps disconnected or with interposed cells and switches. Neither of these are Lane Fox, but all systems which have worked use one method or the other.

Lane Fox's case is not supported by the evidence, and amounts to this:—

Automatic Action by having Large Surface—(*a*) This is a fallacy, for chemical action is the reason for 110 volts being necessary, whatever capacity of cells; if surface increased, more current at same pressure required to do the work of storing up the energy; (*b*) Lane Fox was thinking of internal resistance of cell, not of chemical work to be done; (*c*) Batteries we use are large (Mr. Barrett describes them as enormous); (*d*) No sufficiently large battery ever thought of or made; (*e*) Prof. Perry suggested that same result could be obtained by using a small current with our cells; but all our experiments showed that this could not put in anything in the way of charge. Therefore patent would not work.

3. There is disconformity between provisional and complete:—(*a*) Use of batteries as reservoirs is not use for flicker regulators; (*b*) use of batteries as reservoirs is not use for dotting about to get over loss in leads at times of heavy load; (*c*) use of reservoirs is to add supply, and not to keep constancy; (*d*) the provisional use must at least be good invention, or there can be no development in complete.

4. Disclaimed invention is different from original complete invention.

5. *Insufficient Description.*—That the directions given for carrying out the invention are so vague as to be insufficient in the then state of knowledge. (*a*) Plates. "Very large conducting surface." (*β*) Even if switches and extra cells could be read in to the specification no directions how to use such novelties.

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SECOND.—*Defendants' Cross Appeal.*

1. Patent invalid because earth (globe) or gas and water-pipes would not work:—(*a*) Because one method of "obtaining light by electricity" is the connecting of the negative pole of the lamp with the globe or gas and water-pipes;* (*b*) because earth an essential part of invention and part of merit. (I.) Because of saving in cost of return copper conductor. (II.) Because Lane Fox thought the globe was a vast reservoir of electricity, and the current once passed into the earth by an earth plate, and the dynamo connected by an earth plate, the necessary circuit would be formed with no resistance such as there would be in case of a return wire, corroborated by use of batteries dotted about to supply at different points, so as to enable station current to be always same quantity, and so prevent loss by resistance to heavy current; (*c*) earth means globe in specification on both views—*see* books; (*d*) earth means globe—*see* evidence; (*e*) earth would not work—*see* evidence; (*a*) would not take current; (*β*) corrosion of earth plate or pipes; (*γ*) uncommercial size of plate; (*δ*) removal of pipes for repairs, &c.; (*ε*) pipes are not continuous conductors. (A) Joints. (B) Chemical compound covering pipes; (*ζ*) resistance of earth plate or pipes will vary in proportion as soil is dry or damp. The pressure absorbed in overcoming resistance will have, therefore, to vary, which will necessitate pressure on mains varying.

Now, we have proved that patent invalid because earth (globe) or gas and water pipes would not work.

Subject matter: (*a*) Parallel distribution old; (*b*) batteries old; (*c*) combination old; (*d*) use of batteries as reservoirs, with a generating source of supply and consuming device old; (*e*) use of batteries as reservoirs to take up and provide supply obvious; (*f*) use of batteries for momentary flicker, *i.e.*, demand not in patent; (*g*) if it was, *old.*

Note.—Provisional use only to be considered in novelty and merit.

Note.—Plaintiff's object and invention (if any) is to dot batteries about system, so that dynamos at central station shall always be generating the same volume of current *whatever the demand*, the batteries supplying the extra current from each point of the mains, thereby having a fixed amount of pressure only absorbed in overcoming the resistance in leads to the flow of current, and by this means keeping the pressure at each particular point of the mains constant.

Infringement.—Defendants do not infringe because (*a*) Insulated return used by defendants not earth return; (*b*) use of secondary batteries entirely different. Vary certificate as to issues (*a*) earth; (*b*) subject matter; (*c*) use of secondary batteries entirely different.

I. Plaintiff's object and invention (if any) is to dot batteries about system so that dynamos at central station shall always be generating the same volume of current whatever the demand, the batteries supplying the extra current from each point of the mains. thereby having a fixed amount of pressure only absorbed† in overcoming the resistance in leads to the flow of current, and by this means keeping the pressure at each particular point of the mains constant. Whereas the defendants use the batteries simply as reservoirs to supply current from the central station. They rely upon their feeders to keep the current constant for delivery to the lamps all over the system at 100 volts, varying the size and length of their feeders carrying the current from their central station. That is, their feeders and not their batteries provide for loss through resistance in passing the current through mains.

II. Plaintiff alleges he uses batteries to regulate, defendants use them for storage to replace dynamos, their constancy of pressure is provided for by mechanical contrivances for regulation of engines.

Vary certificates as to issues.

ANSWER OF MR. LANE FOX TO "SUMMARY OF COUNSEL'S ARGUMENTS FOR DEFENDANTS."

Note.—Only a very little important evidence is here cited.

FIRST.—*Lane Fox's Appeal.*

1. It is not disputed that full battery has higher voltage than empty, whatever be the surface; neither is it disputed that if large currents are forced into and drawn out of a small battery, there may be considerable difference in the voltage of the charging and discharging curves. Such difference in voltage, however, means waste of energy. With charging and discharging currents of any amounts from large enough batteries there are only small differences in voltage between charge and discharge, even for considerable periods. Ayrton states that his curves are for the largest currents which the manufacturer thought it safe to use. Even Crompton (*see* question 7,407) published a statement long before this trial of very much smaller percentage differences of potential from complete charge to complete discharge than are shown on Ayrton's curves. Even in the most extreme case Ayrton's curves from point B in charge to point B′ in discharge only show a total change from 110 to 98, or less than 6 per cent. up and 6 per cent. down, taking the normal voltage of the mains and lamps at 104. Mr. Justice Smith admits that this range of 6 per cent. above and below normal may be used in practice (*see* lines 32 and 33, page 782). Mr. Justice Smith seems to have thought that the lamp must be a 100-volt lamp; whereas lamps of various voltages are used, and obviously a 104-volt lamp would not be injured at 110, according to Mr. Justice Smith's judgment.

2. If it is necessary to charge 50 cells above 110 volts, let normal pressure of mains and lamps be 110 or thereabouts; or use fewer cells if normal pressure of mains 100 volts. (*a*) Sufficient storage depends on size of batteries: but even taking Ayrton's curves, about three-quarters, full storage capacity of cell is obtained without passing 110 volts, and within 6 per cent. up and down range. (*b*) Flicker is regulated at all points of charge and discharge of cells. (*c*) Planté's batteries did not deteriorate; and he expressly states that bubbling, *i.e.*, high voltage, is undesirable—(Bramwell, 4,373), (Forbes, 3,927 to 3,931), (Barrett, 3,316 and 2,265). Lane Fox system can be worked without switches; also switches were obvious additions (Barrett's evidence and Lane Fox, 1,985).

Lane Fox case is supported by evidence.

(*a*) Chemical action is cause of static voltage (*i.e.*, voltage on "open circuit" when battery is neither charging nor discharging) whether full or empty. Why do defendants refer to this as applying only to 110 volts? This is most misleading, as chemical action applies to all static voltages of a cell whether full or empty. Moreover, point B on Ayrton's curve (110 volts) is considerably above the static voltage at that moment (Crompton, 7,531 to 7,532). The second part of (*a*) is in plaintiff's favour, for it also means that the same current at less pressure is required, as battery has larger surface, which is his contention; (*b*) he was thinking of both; (*c*) this is a purely relative matter; the defendants' batteries cost only a very small percentage of whole capital; (*d*) *see* Drake (9,097); (*e*) *re* Crompton's cell—*see* remarks, page 674, lines 35 to 45. Crompton's results untrustworthy; contradicted by King's and Drake's curves. *See* also Crompton, question 7,407.

3. There is no disconformity. (*a*) Use of word "reservoir" implies regulation; (*b*) mere amplification of provisional; (*c*) use to keep constancy implies use as a reservoir; (*d*) provisional use was invention, as even the system of lighting (which is part of the combination) was new. It is, however, the combination which is relied upon.

4. This objection is based on theory that regulation is different from keeping constancy of pressure. No justification for this theory.

5. Contradicted by evidence. No evidence in support. Bramwell, 4,108 to 4,110, and *see* Plimpton Skate, case 3, Chancery Division, page 570, as to size of working parts. Switches well known—*see* Bramwell.

SECOND.—*Defendants' Cross Appeal.*

1. Use of term "earth" in specification suggested to every electrician; in 1878 the necessity for a suitable return, however, obtained. This probably points to corrosion, and is a purely commercial question. (*a*) Note to (*a*) misleading and fallacious; (*b*) and (*c*) earth used in description and figures in specification for sake of clearness and simplicity. Very difficult to draw Fig. 5, showing return by cable, without using two colours. Earth is not an essential part of invention (*see* Bramwell); (*d*) contradicted by all plaintiff's witnesses and see books; (*e*) even if earth is held to mean soil it would work in small installation; (*a*), (*β*), (*γ*), (*δ*), (*ε*), (*ζ*), *see* Hopkinson, questions 4,956 to 4,960.

Subject Matter.—General Note by Lane Fox.

The idea of supplying electricity to incandescent lamps in parallel, as gas and water are supplied, was new in 1878 (Perry, 53 and 735-738; Lane Fox, 914-938; Barrett, 3,225-3,236; Thompson, 2,841-2,845). To carry out this idea it was necessary to have constancy of pressure (we use word "pressure," not used before 1878, because the analogy with gas and water was not known), and everything described in specification is for this purpose. This is the essence of patent combined with the system; he, therefore, uses secondary batteries for balancing or regulation, and even now this is important (Miller,). Nothing like the system of lighting itself, or the use of a resorvoir for balancing or regulating in combination with such a system, was known to Clark and Achard, or was anticipated by anybody (*see* Perry, 39-41; Clark and Achard's reservoir, Perry, 120; Lane Fox's reservoir, Perry, 119; Perry, 289-311; and all plaintiff's witnesses. *See* also Clark's specification, page 3, lines 16-21; also page 7, lines 5-10).

Answers to Defendants' Arguments.

(*a*) System of distribution, net-work of mains at nearly constant pressure and high-resistance lamps new; (*b*) admitted; (*c*) combination quite new. (*d*) and (*e*) *See* Perry, questions 39 to 42. Analogy, air-gun old user, fire-engine air-vessel new user. (*f*) Incorrect. Included even in provisional by use of word "reservoir" and context (Perry, 91 and 98). (*g*) Absolutely no evidence.

Note.—Absolutely denied (Crompton, 7,224 to 7,226).

Infringement.—(*a*) Defendants use an equivalent return well-known in 1878. (*b*) Contradicted by evidence.—*See* Bramwell, questions 4,486-4,491. *See* Hopkinson, question 5,297.

I. Plaintiff intended to keep same pressure all over mains—*see* Crompton, questions 7,224-7,226. Feeder mains a simple amplification or improvement of Lane Fox system. This also applies to switches.

II. Contradicted by evidence—*see* Crompton, question 7,392; Miller question 8,055 to 8,063.

* We do not know which way the flow is; and the direction as to return, as it is called in this, the very first system of electric lighting, is most necessary, witness telegraphy and arc lighting, the only other electrical applications known, for there earth could be used.

† If current increased more pressure would be lost in overcoming the resistance of mains.

Stone v. Metropolitan Electric Supply Company.

Recently, at the Bloomsbury County Court, his Honour Judge Bacon heard the case of "Stone v. the Metropolitan Electric Supply Company," which was a claim for one week's wages in lieu of notice. The plaintiff is a stoker, and said that he was engaged by Mr. Allborough, the superintendent of the Company, on trial, and subsequently taken on the staff at 30s. 4d. per week of seven watches. He was a union man, and as there was some trouble with union men on the works, he was discharged along with others on Monday, May 2nd. He was only paid for one watch, although he asked for a week's wages in lieu of notice. He had since been unable to get employment in London owing to the "row," and he

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now brought this action as much to vindicate his character as to recover the money due to him.

The defence was that it was customary for companies to dismiss stokers on a watch notice, or to pay them for a watch.

The Judge said that he thought that in such work as this electric supply, where anything like a strike or sudden caprice on the part of the men might cause injury to employers, it was not unreasonable that the men should be liable to dismissal at the termination of one period for which they receive their wages. He (the learned judge) was satisfied that this man was employed by the eight hours, and was not entitled to a week's notice.

Judgment for the defendant company.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—Firms wishing to tender for the supply of mains and fittings in a large block of City offices are invited to communicate in writing to Major-General C. E. Webber, Portland House, Basinghall-street, E.C., by Monday, the 18th inst.

——— Tenders will be received up to 12 noon on the 25th instant by Messrs. Milnes and France, architects, 99, Swan-arcade, Bradford, for the works required in the erection of the buildings for the Leeds Electricity Works.

TENDERS RECEIVED.—Five tenders have been received by the Electrical Committee of the Bristol Town Council for the supply of the condensing plant for the electric light installation, and have been referred to Mr. Preece, the consulting electrician, for his advice thereon.

——— The Public Lighting Committee of the Basingstoke Town Council have reported that they have received a tender for lighting the town by electricity, but that the amount was too high for them to recommend its acceptance. The gas company had made a considerably-reduced offer for lighting the streets, which was agreed to by the Council.

PLANT FOR SALE.—Messrs. Wheatley Kirk, Price and Goulty set out in our advertising columns particulars of high-class engines, boilers and other plant which they have for sale. These include several complete installations for arc and incandescent lighting. Particulars and lists can be obtained on application to Messrs. Wheatley Kirk, Price and Goulty, 52, Queen Victoria-street, E.C.

SALES BY AUCTION.—Messrs. Brodie, Timbs, and Baker, auctioneers, 68, Finsbury-pavement, E.C., announce in our advertisement columns that, by order of the liquidator, they will sell by auction, on the premises, 37, Tabernacle-street, E.C., on Tuesday next, the 19th inst., the valuable stock and machinery belonging to the Vaughan-Sherrin Electrical Engineering Company, Limited (in voluntary liquidation), including an Otto gas engine, an Elwell-Parker compound dynamo, &c.

——— Messrs. H. N. Newton and Co., auctioneers, 67 and 69, Chancery-lane, W.C., will sell by auction, at the Phœnix Works, Boleyn-road, Dalston, on Thursday next, the 21st inst., a quantity of nearly new and valuable machinery, including a 12 H.P. vertical engine, an 8 H.P. and a 3 H.P. gas engine, screw-cutting lathes, drilling machines, &c. Further particulars appear in our advertisement columns.

WOODHOUSE AND RAWSON UNITED (LIMITED).—In reference to the report that this firm have removed their head offices from Queen Victoria-street, we are able to state that these head offices will remain at the old address, 88, Queen Victoria-street, E.C., but that for the future the firm are storing the bulk of their specialities at Hammersmith.

THE ELECTRICAL COMPANY (LIMITED).—The business heretofore carried on under the name of Keys' Electric Company (Limited) has been reconstructed, and will be carried on in future under the above title. Mr. F. T. Eggers is the liquidator of the old Company.

EPSTEIN ACCUMULATORS.—We are informed that the Birmingham Central Tramways Company have just placed an order for 600 Epstein cells with the Midlands branch of Woodhouse and Rawson United (Limited) for use upon their electric car route.

MESSRS. DRAKE AND GORHAM.—This firm have received the contract for the work in connection with the additional installation at the Harrow Schools, and also for an installation at Hartsdown, near Margate, and a water-power installation for the Duke of Montrose at Buchanan Castle.

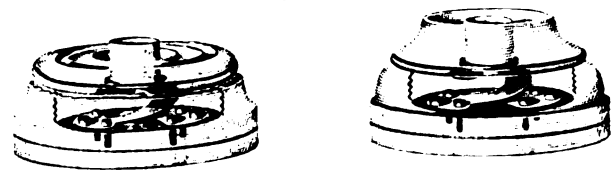
MR. A. A. C. SWINTON.—"Chesters," Northumberland, is to be electric lighted under the auspices of Mr. Swinton, the installation consisting of about 330 incandescent lights.

GENERAL ELECTRIC POWER AND TRACTION COMPANY (LIMITED).—This Company have received instructions from the War Office to erect a five-ton electric travelling crane at Woolwich Arsenal. The firm have also just added another dynamo to the extensive plant at Messrs. Locke and Co.'s, St. John's Colliery, Normanton. This machine was started on Saturday last.

PROPOSED ELECTRIC LIGHTING FOR LEITH DOCKS.—The Leith Dock Commissioners, at their last meeting, had submitted to them part of a report regarding the cost of the introduction of electric light into the docks, from which it was gathered that the estimated cost of engines and other necessary plant would be £8,000, and the annual maintenance of the light £2,000. The Clerk stated that the annual cost of gas was about £2,197.

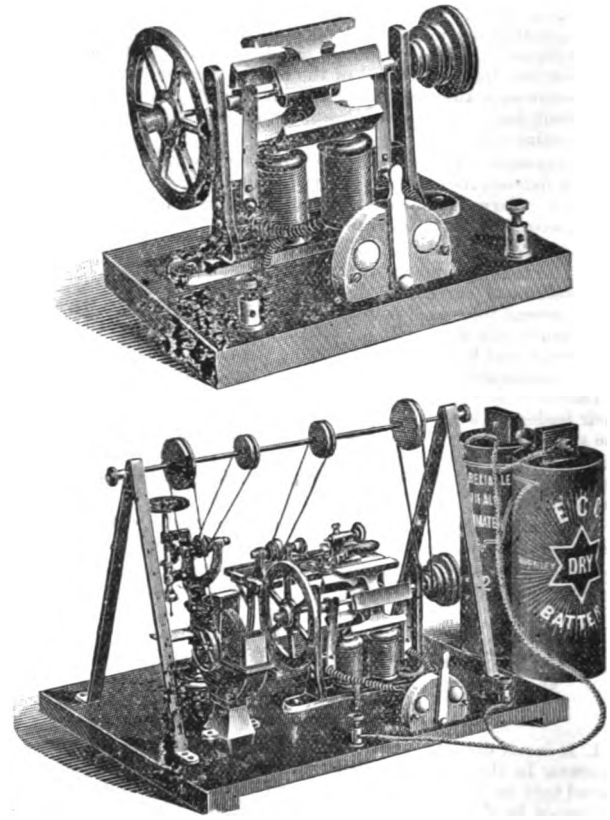
MUIR, MAVOR AND COULSON (LIMITED).—A meeting of the shareholders in this Company (in voluntary liquidation) will be held at 139, St. Vincent-street, Glasgow, on August 10th, at 12 noon, to receive an account of the winding up.

GENERAL ELECTRIC COMPANY.—This Company send us specimens of a new porcelain electric bell-push, which we herewith illustrate. The cover screws on with a good thread, and the plate and spring are screwed on to the back by a pair of brass screws, the holes



New Porcelain Bell Push.

being tapped in the porcelain, but not coming through. A third screw on each plate is provided for the wire. The bell-push is most substantial, and an improvement on many of the usual patterns with wood or ebonite backs. The Company also send for



A New Toy Workshop.

our inspection a toy workshop, driven by an electric motor, for which they expect a considerable demand at the coming Christmas-tide. Some idea of the working of this novelty will be gathered from the illustrations.

HERBERT W. HOOPER AND CO.—The following are among the creditors of Herbert W. Hooper, carrying on business as an electrical engineer, at 17, Prince's-street, Hanover-square, who, as reported in last week's *Electrician*, has filed a deed of assignment:—

Acme Electrical Works, London	£19
Day and Co., London	17
Edison and Swan United Electric Light Co. (Limited), London	30
General Electrical Company (Limited), London	12
Girdlestone, Tatham and Co., London	15
Glover (W. T.) and Co., London	21
Godfrey, Giles and Co., London	36
India-rubber, Gutta-percha and Telegraph Works Co. (Limited), London	14
Munro's Electrical Manufacturing Co. (Limited), Glasgow	33
Poole and White, London	24
Tautz, E., London	67

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COMPANIES' MEETINGS & REPORTS.

National Telephone Company (Limited).

The twelfth ordinary general meeting of this Company was held yesterday (Thursday) at the City Terminus Hotel, Cannon-street, under the presidency of Mr. James Staats Forbes.

The SECRETARY (Mr. Albert Anns) having read the notice calling the meeting, the report of the Directors was taken as read.

The CHAIRMAN, in opening the proceedings, referred with great regret to the loss which the Company had sustained by the sudden death of the late Chairman, Mr. F. R. Leyland, to whose devotion to the interests of the Company he warmly testified. Passing to the report, he stated that the income for the past year had been £463,741, which was £32,600 more than in the previous year. Their subscribers paid in advance, and also for intervals of time not limited by a particular year. A man, for instance, might come in as a yearly subscriber on January 1st, whereas the Company's business year ended on April 30th; and, therefore, as they took the subscription in advance for 12 months, obviously only a portion of the amount could be attributed to the part of the year to which it applied. A table at the end of the report gave an abstract of the accounts for the past three years, showing full details as to the earnings, and how the receipts were applied. All the details were given in this abstract, and he thought it would be most useful to continue this information from year to year, so that the shareholders might be enabled to see at a glance what the financial aspect of the Company was in relation to income and profits. Concurrently with the increase in the income of the year there had been a considerable increase in their expenditure upon capital account, and the net income had become chargeable to the extent of about £18,000 on account of this additional outlay. If they came to consider the increase he had mentioned of £32,628 upon so large a figure of income as £431,000, it did not seem too brilliant, as it was only 7 per cent. on the whole, but certain points in connection with this increase had to be borne in mind. For instance, they had had to anticipate certain things, and looking forward they had thought that the time had arrived, as the period of the patent expired, for relieving the subscribers of some portion of the charge which they had hitherto paid. The present was the first complete year in which the alteration thus made applied, and the reduced rates amounted to no less than £55,000, assuming that they had kept the same number of subscribers. Other considerations, which he detailed, brought up the amount to £65,500, by which their revenue had been reduced in the past year compared with the previous year. It was all very well to say, "Reduce the amount you charge for subscriptions," but it was to be remembered that the amount of the reduction would all come out of one pocket—that of the shareholders. Having had more work to do their expenses had also increased, having amounted to £236,252, or £36,768 more. In face of these circumstances, of course, there would naturally be a diminished net revenue, and the decrease had amounted to £7,797. Notwithstanding the drawbacks he had mentioned, they had had an increase in their gross income, and the number of their subscribers had increased under the influence, more or less, of the reduction they had made in their charges. The increase in their business had been 20 per cent., and the cost of conducting the business had been higher by 18 per cent. They would, therefore, see that the expenses had only kept pace with the increase in the number of their subscribers. It should be remembered that the royalties which they paid to the Post Office were on their gross receipts, and not on their net income. Out of the divisible balance, after providing for interest on debenture stock, an interim dividend for the first-half year had been paid at the rate of 6 per cent. per annum on the preference shares and 5 per cent. per annum on the ordinary shares; and out of the balance, notwithstanding the operation of the circumstances he had mentioned, there remained enough to pay a further dividend for the past half-year at the rate of 6 per cent. per annum on the preference shares and 7 per cent. per annum on the ordinary shares, making the distribution on the latter 6 per cent. for the year. There then remained a balance of about £15,000, and they proposed to carry to reserve account £10,000 of this amount in addition to £1,127 placed to reserve during the year from premium account. This would bring up the reserve account to £104,627, which was a very substantial figure. He thought they would see from what he had said that they had been very wisely discounting the future with a view to discouraging competition. They had emerged from protection into the more healthy atmosphere of free trade, and their object had been to take care that their service was made not only efficient but that their charges should be so moderate in relation to the value of the work done by them that their customers should not be tempted by competition. They had added to capital account during the year £320,991, the bulk of which had been spent on attaching subscribers, and as regarded £95,000 of the amount, it represented their outlay on laying trunk lines. Their business was made up of two things—their local service in a given area, where they invited subscribers to the local exchange or exchanges, and the means of connecting those areas—London, for instance—with more distant places, say, Manchester or Liverpool. Their through wires were enormously valuable to them, because they might be made to pay by themselves a reasonable dividend, in addition to which they acted as an inducement in attracting local subscribers, who might not in many cases be disposed to pay for merely local exchanges. As he had said, the increase in their lines had been 20 per cent., which they would see represented a considerable number of new subscribers, and the cost of installing the lines had been £250,000. The net revenue had slightly diminished, having been charged with its increased burdens. The balance sheet contained two entries relating to the purchase of the telephone business of the Sheffield Telephone Exchange and Electric Light Company, £40,619, and the purchase of the undertaking of the Caledonian Telephone Company, £4,500. These were items accruing due in respect of the purchase of these businesses when all the details and preliminaries connected with the agreement were determined. These matters had to be settled before they parted with their money, but he might state that they had acquired on very advantageous terms the two businesses he had mentioned. Paragraph 8 was a somewhat important one, as it opened up a very large question, and threw on the Board a most serious responsibility. The Company were universal licensees—that was, they had the privilege within the whole of the United Kingdom of laying down lines, opening exchanges, fixing rates, and conducting their business in their own fashion. That was a policy that was initiated by a man who had considerable claims to statesmanship—the late Mr. Fawcett, when he was Postmaster-General—in contradistinction to an earlier policy, which was to limit their lines and powers. That policy was tried and found wanting. The expansion of telephones throughout the kingdom was impossible under this state of things, and Mr. Fawcett was wise enough to see that, as the result of experience. He accordingly broke down all bounds and left the Company free, and they had gone on for several years spending their money and incurring risks upon the faith of that contract—that they should be free to do these things. There was one blemish in the matter—that was, that all they did was on sufferance. They had no legal status, no legal powers, and he thought it marvellous that their enterprise had been built up absolutely on sufferance. They had no legal rights in regard to putting up any wires or posts, and yet they had done so; but this state of things had resulted in this—that the telephone in England had not advanced in relative user or in relative perfection with its advance in other countries where the conditions were different. If they had had legal powers to do all those things which must be done in order to make an efficient service they would have done it long ago. What he had stated ought to be borne in mind by those who went about talking of the relative iniquities of their poor Company, and compared it with institutions where the Government had everything in their hands and could do as they liked, their Company, as he had already stated, having absolutely no legal powers whatever. They had been knocking at the door of Parliament for several years, to ask them to let the Company do what the subscribers and the public had complained that they did not do—give an efficient service and expand their business; but the Post Office would not let them in. This was a question affecting the public interest. The Post Office bought the monopoly of the telegraphs at a price which made them very uncomfortable, and the policy of the Post Office with reference to telephones until lately had appeared to be to leave them to struggle as best they could in the prosecution of their business, but by no means to help them. He did not complain of the Post Office. It had a business, purchased at an enormous price, and at the risk of the taxpayers, not of shareholders, and the Post Office were bound to protect their revenue. Protecting their revenue, however, meant not giving too many facilities to the telephone, because, as sure as morning followed night, the telephone was going to supersede the telegraph to a very great extent. This was illustrated by one or two figures. The Post Office was a Government department, with all the prestige of the State. They could do things which a private company could not do, and the constitution of the public was so singular that they would take at the hands of a State department what would be regarded as insufferable at the hands of a private monopoly. With all the advantages possessed by the Post Office, however, he found from their last book year that they transmitted, having been in existence a good many years, 66 millions of telegrams. They had popularised their service by 6d. telegrams. They had, however, wiped out their revenue entirely, but the State did not pay for this. They had no shareholders but the taxpayers. Their 66 million of messages cost the people who sent them something very nearly approaching 9d. each. Their Company, however, carried on a very reasonable approximate estimate—not at 6d., the message being limited to 12 words, of which very often the address and signature meant 6 words—but communications, so to speak, oral to the extent of 160 millions, and at a price approximating to 1½d. each. These communications, too, did not include the addresses, because they found out the addresses themselves, and put the people in communication with each other for nothing. He would like to ask them to measure the difference by this standard of the two services. Supposing the 160 millions of oral communications had been charged according to their value merely as measured by the words that passed, he supposed that the average of the communications would mean, not 12 words, but 40 or 50. If they worked that calculation out at ½d. a word, they would see what they arrived at; but he had put it rather high at 1½d. And this was going on, and the State had suddenly awakened to the position. The Company had been howling because they could get no powers. A Committee in 1884 heard the whole story, and they reported that it was a matter of such grave public importance that every restriction should be taken from it, and that it should be assisted. Nothing, however, had been done in the matter until now. Mr. Goschen was a very able man, and, no doubt, as Chancellor of the Exchequer, had had his eye on the Post Office telegraphs for the purposes of revenue. The Post Office authorities had had the Company's Bill before them, and the Company received notice that it was not to be proceeded with. Still, it did what it was intended to do—it brought the question to a head; and the Government had determined on a policy under which it was proposed that all the trunk lines used for inter-town telephonic communication should become the property of, and be worked by, the State, the exchanges and local service remaining in the hands of the Companies for the term of their present licences. This policy reversed to some extent the policy of Mr. Fawcett. It set up barriers—that was to say, the Companies or the Company as the licensees were to be entitled to areas to be determined by the

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Government to carry on its business of exchanges, but it could not break bounds except through the Government instrument—the trunk wires. A man in London, therefore, could not communicate outside a particular area; but what the particular area was to be was not defined. They knew what their present area was, but they did not know what it was to be. It seemed, therefore, to come to this, that the policy to which he had alluded as inaugurated by Mr. Fawcett was reversed, and they were to be restricted to certain areas, and without any powers—or, at all events, with powers so shady that they did not seem to be worth much. This appeared to him to be retrogression. The Treasury Minute which had been published explained the policy, which was very curious. It was a hit at monopolists. It said, what was perfectly true, that their Company, having had to begin the business, having had to take all the risks of its imperfections as a new discovery, and all the risks of applying it without legal powers—having invested their money in this state of things, they were now to go back to a limited area. Of course, they had very valuable connections through their trunk wires to London with hundreds of towns which could intercommunicate with each other. The proposal was that they should surrender this intercommunication and hand it over to the State In virtue of that surrender they were to be left in certain areas and to have certain privileges given to them in the way of conveniences of some value for their subscribers; but they considered that that alone as an equivalent was not very much. The surrender of their trunk lines deprived them of just those advantages which the Treasury Minute declared to be a monopoly in the hands of a private company. They would probably become a monopoly, because, having covered England with trunk wires, it would be very difficult for other people to follow them. This was an accurate argument out of the mouth of the Post Office. The carriage of letters, however, was a monopoly, and certainly the telegraphs were a monopoly; and the telephone could not be separated from the telegraph. They could run together, they might bring one to help the other; but the proposal of the Government was a half-and-half measure. It brought in a dual control, it would not facilitate either the promptitude or the simplicity—he was not sure that it would promote the economy—of the telephone. The proper thing to do was for the Government to acquire the thing; but they did not do this. The shareholders would see what a delicate and difficult position the Board was in. They might agree with the Post Office to surrender their present constitution, which gave them universal power as far as they could exercise it, and they might accept limited powers; but they did more or less put themselves in the hands of the Post Office. It was true that they were free not to agree; but then, said the Post Office, "If you do not agree, some one else will. We will promote people who will, and will afford them the means of trunk communication from one end of the kingdom to the other, and competition with you will then be a very easy matter." Upon this and other grounds they had made up their minds that they ought to agree with the Post Office, because, as licensees of the Post Office, their relations were so dependent on that department in many ways that mere prudence and loyalty would involve their doing everything they could to make this policy succeed. But, of course, it was at present "Hamlet" without the chief character. The Company wanted to know what the consideration was to be. The surrender of the trunk wires was a condition *sine qua non*. This meant some important consideration. The cost of the trunk wires was not an equivalent, because if they surrendered these wires at the price which had been paid for them, they would not only give up the trunk wires, but also the 19 years' enjoyment of the profit which the lines were put up to earn, and which they would earn, and earn in growing quantities. The matter depended on their getting fair terms, and they were now in negotiation with the Post Office. At the present moment, however, a little complication had arisen as to the future. It was easy to negotiate with responsible heads when they were there, but when they were not, one must wait and see what turned up. This was a matter of the gravest public moment. If the telephone service of the country was to be conducted efficiently and economically it must be in the hands of one or the other. It was as much a monopoly in the nature of it as the transmission of telegrams or the conveyance of letters was; and although competition was a favourite thing and always took with the public, the latter were so blind that they would not see that combination followed competition as surely as night followed day, particularly in a business of this sort, where the areas were narrow, the difficulties great, and the multiplication of capital and control meant, not simplicity and economy, but competition and wastefulness. The Government, therefore, ought to do one thing or the other. They ought to recognise that the telephone was in the nature of it a monopoly, and commit the conduct of the business to licensees under proper Government restraint, or they ought to do it themselves; and he ventured to predict that their attempt to do a big thing in a weak-kneed manner would not succeed. Notwithstanding that, however, the Company would not be absolved from doing all in their power to make it succeed. It would be unfair to throw upon the Directors such an immense responsibility as to determine the whole future of the Company upon an agreement the result of which no man could absolutely clearly predict. One might have some idea as to what might happen, but it would be more or less a jump in the dark. The business of the Company was increasing. They had added to it certain subsidiary lines—among others the important centre of Sheffield, where there was not only existing competition, but the threat of further competition at the hands of new people. They had bought this enterprise up at a price which, in reference to the secured income at present and the security from disadvantage in the future, was a very moderate sum indeed. Sheffield was a great centre of industry, and the Company's nets were spread wide, their strength depending on having in every centre in their subscribers friends as well as customers; and this meant that in these centres gentlemen of position and knowledge should be with them who could excite the sympathy of the subscribers and keep in touch with them. In view of this important consideration, Mr. George Franklin had been appointed a Director, he being a gentleman who was well known in Sheffield. As their business was getting very large and complicated, and its ramifications were extending from day to day, they had appointed Mr. William E. L. Gaine as general manager, he being a gentleman who had had practical opportunities of conducting a great organisation and carrying out a business more or less analogous to their own. He concluded by moving the adoption of the report and the payment of the dividends recommended.

Colonel R. RAYNSFORD JACKSON having seconded the motion, a brief discussion followed.

The CHAIRMAN, in reply to questions, stated that their wires, poles, machinery, &c., were always changing their character, and what they did was to maintain their structure out of revenue. If a pole or any of their machinery became bad it was replaced at the cost of revenue, and in that sense the depreciation of the undertaking was maintained out of its profits. Everyone knew that boards of directors, with members living in London, Glasgow, Edinburgh, Sheffield, and a dozen other places could not sit permanently, and, therefore, they were obliged to delegate the work of the Company to what was called the Executive Committee, to which, under the Articles of Association, the Directors, in their discretion, might award further remuneration, and they had done so to the extent of £5,000 a year. There were, however, 12 Directors. If this was objected to it had better be settled at that meeting. Not one of the Directors considered that he was paid too much, and not one of them was there for the fees which he received. They were among the largest shareholders of the Company. He had heard of the New Telephone Company, but as far as he was able to ascertain, it was a good deal in the air. He hoped that the New Company would be wise in time, and not invest their money in fruitless competition. Their reserve fund was invested in the business of the Company. If that were not so they would have to raise additional capital to the same amount, and he supposed that in the present condition of things they would not be able to raise much money under 4½ per cent. If their business was to progress as it ought to do they would want a great deal more capital. He had omitted to state that the Directors had in their minds the creation of about £1,000.000 of Five per Cent. Stock for the purpose of buying up the undertaking of the Western Counties and South Wales Telephone Company, and for paying for the other businesses.

The resolution was carried unanimously; and the retiring Directors and auditors having been re-elected, the proceedings terminated in the usual manner.

Paris and New York Cable Company.

A meeting of the Paris and New York Cable Company was held on Tuesday afternoon last, at which more than 21,000 shares were represented. American shareholders took no part in the proceedings. The Chairman announced the resignation of the entire Board; whereupon a discussion, lasting over two hours, took place. One of the principal shareholders laid particular stress upon the necessity for the French Company to avoid, in the interests of State secrets, all participation of the American element. A new Board of seven members was elected, representing French interests alone, as follows:—MM. Bruyère Dellorier, Sutterlin, G. Vian (of the old Board), and De Carrère, Salmon Halphen, Bernard, and Pestel (new Directors).

Edison and Swan United Electric Light Company (Limited).

The following is the report of the Directors of this Company to be presented at the ninth annual meeting, to be held at the Cannon-street Hotel, on Tuesday next, the 19th inst., at 12 noon:—

The business of the Company for the year ending June 30th last has resulted in a credit balance of £74,810. 16s. 7d. Of this amount £30,271. 15s. 11d. has been already distributed as an interim payment on the "A" shares for the first six months of the year in respect to dividend and arrears. The Directors recommend a further distribution of a dividend on the "A" shares of the Company, of 5s. 8¾d. per share on the 89,261 ordinary shares, £3 paid; of 9s. 6½d. per share on the 5,000 £5 fully-paid shares allotted to the Edison Electric Light Company (Limited); and of 8s. 10¾d. per share on the 12,139 £5 fully-paid shares allotted to the Swan United Electric Light Company (Limited), free of income tax, being, with the interim dividend paid on February 22, 1892, 7 per cent. in respect of the year ending June 30, 1892; 7 per cent. in payment of arrears of cumulative preferential dividend for the year ending June 30, 1887; and of 4 per cent. in respect of the year ending June 30, 1888; all to be distributed in accordance with the provisions of Clause 87 of the Articles of Association, which will absorb £33,354. 4s. 9d., leaving £11,184. 15s. 11d., which the Directors have carried to the reserve fund, in accordance with Clause 89 of the Articles of Association.

The Directors are glad to say that their electrical fittings business is prospering. The amount received as royalty from those who hold licences for manufacturing holders and sockets for incandescent lamps is satisfactory, and is likely to increase year by year.

The Directors desire to record their sense of the loss which the Company have sustained by the death of Mr. F. R. Leyland. The Directors have elected Major Samuel Flood Page, who had been secretary and manager of the Company since 1883, to fill the place on the Board. The Earl of Lichfield and Mr. Ernest Villiers retire by rotation from the Board, and offer themselves for re-election as Directors. Messrs. Welton, Jones and Co., auditors, also retire, and offer themselves for re-election.

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Chili Telephone Company (Limited).

An ordinary general meeting of this Company was held at Winchester House, London, E.C., on the 8th inst., "for the purpose of receiving the report of the Directors and statement of accounts, the election of a Director, the appointment of an auditor, and for the transaction of the ordinary business of the Company." Colonel R. Raynsford Jackson presided.

Mr. EDMUND PETLEY (the Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, the report we have to present to you is conspicuous for two leading features—one which we may consider adverse and the other beneficial, leading us to hope for better things in the future. The adverse feature is that the profits are less than they were in the previous year. The net profit in sterling for the last year was £6,067, or £7,622 less than the profit for the previous year. You all know why the profits are less than they were. A fierce revolutionary war in Chili has disorganised every interest there, and ours among the rest; and one of the consequences has been a wholesale destruction of lines and poles and works, causing an increase in the expenses involved in carrying on our business. Although the profits are so much less than for the year 1890-1, the receipts in Chili are very little less, and that leads us to hope that we shall have a rapid development of our business. The receipts in 1890-1 were $387,110, while in the year under consideration they were $378,830, being a difference of $8,280, so that the effect of the revolutionary war was to reduce the receipts in Chili by 2½ per cent. only. That was a great change from the previous year, when the increase of gross revenue was 47 per cent., but there were indications that for the remaining portion of the current year their revenue would progress at the old rate. The new revenue secured in April was $7,962, and in May, $7,690, or pretty much the rate of increase which prevailed in 1890-1. This leads us to hope that we are to a great extent passed the disorganisation in Chili arising from the revolution, and that from this time forth we may expect to increase our revenue and to make our position secure. Although the difference of the receipts in dollars in Chili was only $8,280, the expenses were $76,120 more. Then, again, the dollar was worth 19½d. as against 24d. in the previous year, which also militated against the profits as reckoned in sterling. Our position has been altered in some important respects. You are aware that according to the report issued last year we were obliged to conduct our business through our manager, who also required and received the appointment of the West Coast Telephone Company. It was stated also that a minority of the shareholders of the vending company opposed the sanction by the Court of the transfer of the West Coast Company's enterprise to this Company. That opposition has since been withdrawn, and the title of the Chili Telephone Company to their property having been duly and legally registered, we have got over all the difficulties I have referred to. On the favourable side is this further important fact: an arrangement has been entered into with the Government of Chili for the supply of a telephonic service in Chili for ten years, and similar arrangements have been entered into with the authorities of Santiago and Valparaiso. The latter will enable us to erect poles in these two cities, and will give us the support of the municipal authorities in the two largest cities in Chili, strengthening our position, and assisting the development of the Company. Our revenue has now reached $400,000 up to the end of May. This leads the Directors to think that the time has come when they may safely regard the earnings of the Company as legitimately the property of the shareholders in the form of dividend. There is a proposal in the report as to a method of meeting what the shareholders had a right to expect in this particular. All our earnings have been spent in Chili, and treated as capital. That has been done because this is not the time to ask the public to subscribe for shares in any enterprise connected with South America, and if we were to issue capital with the view of putting the accounts between revenue and capital right we should raise our new money on very unfavourable terms. We have thought it expedient that we should issue deferred warrants payable when capital is in hand for the earnings of the past two years, giving an option to the shareholders, any time between now and March 31st next year, of converting their warrants into shares of the Company. The Directors hope that as a rule the shareholders will so deal with these warrants, because the effect would be to increase the capital of the Company in an easy manner to the extent of £20,000. I beg to move that the report and statement of the accounts be received and adopted, and I may add that carrying this resolution does not bind you to the deferred warrant dividend proposal, for which a formal resolution will afterwards be proposed. The first resolution which I beg to move is—

"*That the Report of the Directors, with the statement of accounts to March 31, 1892, now presented to this meeting, be approved and adopted.*"

Mr. THOMAS GREENWOOD seconded the motion.

Dr. J. R. LEESON said that he would like to ask a question in regard to paragraph No. 8 of the report, which stated—"As the bulk of the increased expenditure has been caused by the revolution, a claim has been made against the Government, of which $115,000 remains unpaid. No part of this sum has been treated as an asset in the Company's accounts; whatever may be hereafter received from the Chilian Government will be credited to future revenue." He would like to know as to this claim which had been made how much it was in the first instance and whether any arrangement had been arrived at with the Chilian Government as to payment of the remainder.

Mr. W. J. DEY said that he would like to ask in reference to the deferred warrants when they would be payable, and also whether they would bear interest until they were paid.

The CHAIRMAN: Are there any other questions, because I will answer them all together?

No further questions were asked.

The CHAIRMAN said that in reply to the question of Dr. Leeson as to the $115,000 referred to in paragraph No. 8 in the report, the matter was still under negotiation, and they had made a claim to that extent, but how far that claim would be successful and acknowledged by the Government they were not in a position at the present time to state. With regard to the other question that had been raised, he would like to draw attention to the fact that in the report for the year 1890-91 the accounts were credited with the sum of $62,000 which had been received from the Government, and they had received subsequently about $30,000 more, which had been credited to the revenue of the accounts presented to the shareholders for the last year. As to the question of Mr. Dey, in respect to the deferred warrants, they would not carry interest; but up to the 31st March next they could be converted into shares of the Company. After that time the warrants that were not so converted would be paid when the circumstances of the Company allowed of their payment, but he hoped that the majority of the shareholders would convert their certificates into shares of the Company. If there were no further questions he would put the resolution.

The motion was unanimously carried.

The CHAIRMAN said that the next question that they had to consider was the resolution in regard to the payment of dividend, and he begged to propose—

"*That a dividend of 10s. a share, free of income tax, be declared upon the ordinary shares of the Company, not to be payable immediately, but to be represented by certificates, which may be exchanged on presentation before the 31st March, 1893, for an equal amount of the Company's shares (fully paid, £5 each) entitled to dividend from 1st April, 1892, and that such certificates as may not be so exchanged shall be paid in cash after due notice, at such time as, in the opinion of the Board, the state of the Company's finances admit of such payment being made.*"

Mr. THOMAS GREENWOOD, in seconding the motion, said that of course these deferred warrants would bear no interest whatever, although the shares into which they could be converted would be credited for dividend. It was therefore distinctly to the interest of the shareholders to make that change and to convert the warrants into shares, as otherwise they would be without dividend and without any interest upon their money. By this means £20,000 of capital would be raised which otherwise would have to be obtained in another way, and their shares not being worth par any issue would not be very much in favour with the public, and therefore the shareholders would be manifestly helping the enterprise themselves by bringing in these deferred warrants and converting them into shares of the Company. With regard to the conversion of the deferred warrants into shares he was desirous of pointing out that this conversion must take place and the deferred warrants must be presented before March 31, 1893, or otherwise the privilege of converting the warrants into shares would be gone. As to the point that had been raised in regard to the date for the payment of the deferred warrants in cash which were not converted into shares, they could not possibly at present fix the time because they could not be paid until they had earnings sufficient to meet them, and, as the shareholders were aware, the present cash resources of the Company were low, and they had not got the wherewithal to pay these warrants at the present time. Of course some shareholders might prefer to sell their warrants rather than to hold them or to convert them into shares; he knew that such an impression had got about, and if they so desired it was at their option to do so, and get a smaller dividend in cash by the sale. He had taken the trouble of giving these particulars in regard to the proposals in respect to these deferred warrants, because, although there were so few shareholders attending at the meeting that day, a report of the proceedings would, no doubt, be sent to the shareholders who were absent, and they would thereby have the means of receiving information which they would probably desire, but which, otherwise, they perhaps would be unable to obtain. He commended the acceptance of the resolution to the shareholders.

The resolution was put and unanimously carried.

The CHAIRMAN stated that the next business was the re-election of the retiring Director, Mr. Frank W. Jones, who was a very valuable member of the Board, and who had previously been connected with the West Coast Telephone Company. Mr. Jones took a very great interest in the affairs of the Chili Company and had experience of the country, and he (the Chairman) hoped they would re-elect him. He formally moved—

"*That Mr. Frank W. Jones be and he is hereby re-elected a Director of this Company.*"

The Hon. F. E. ALLSOPP seconded the motion, which was unanimously carried.

The CHAIRMAN stated the next business rested with the shareholders. It was the re-appointment of auditors.

Dr. LEESON proposed the re-election of the retiring auditor, Mr. T. A. Welton.

Dr. WALTER JOHNSON seconded the motion, which was carried.

On the motion of Dr. LEESON, seconded by Mr. DEY, a cordial vote of thanks was accorded to the Chairman and Directors of the Company.

The CHAIRMAN in returning thanks expressed a hope that they would ultimately bring the Company to a success which would be satisfactory to the shareholders.

The proceedings then terminated.

Western Counties and South Wales Telephone Company (Limited).

An extraordinary general meeting of the shareholders of this Company was held at the Grand Hotel, Broad-street, Bristol, on Friday, under the presidency of Mr. George Nash, for the purpose of confirming the resolu-

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tions passed at the extraordinary general meeting held on the 21st ult., approving the transfer of the business and property of the Company to the National Telephone Company (Limited). (See *The Electrician*. June 24th).

The CHAIRMAN formally moved that the resolutions be confirmed, and this was seconded by Mr. MARK WHITWILL; and after some remarks by Mr. G. WHITE, criticising the action of the Directors in carrying out the transfer, the resolution was put to the meeting and carried.

Telegraph Construction and Maintenance Company (Limited).

In accordance with the resolution of the general meeting of February 28, 1871, a half-yearly general meeting of this Company was held on Tuesday at the offices, 38, Old Broad street; Sir George Elliot, Bart., presiding.

Mr. WILLIAM SHUTER having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, this meeting, as you are all aware, is not convened for the purpose of making any kind of investigation into the accounts of the Company, but is rather a kind of recognition of the goodwill existing between the shareholders and the Directors. I remember many years ago when the meeting was founded, and that is the view we took of it. I will just briefly read to you a few things which have happened since we last met. During the past half-year we have carried out a contract with the Western and Brazilian Company by laying about 770 miles of cable along the coast of Brazil (between Santos and Chuy), and have made various repairs in that Company's cables on the same coast. We have laid a cable nearly 300 miles in length along the eastern coast of Sumatra for the Dutch Government (through the Eastern Extension Company); we have made several repairs in the German Government cable between Emden, on the river Ems, and Valentia, in Ireland: and we have likewise made repairs in the Direct United States Company's cable on the banks off the coast of Nova Scotia. Our general business—which is business outside cable laying—has been fairly good compared with the similar period of last year. I do not know that there is anything of a commercial or controversial character that arises beyond what I have stated. We meet merely, as I said before, rather to feel that we are going on quietly, doing our best, and also in the belief which I hold that the Directors have the entire confidence of the shareholders. The Directors, too, have great confidence in the concern itself as being *bonâ fide* in the interests of the shareholders. We never have any resolution at this meeting, which is a kind of *réunion* among ourselves each half-year. That is the whole of the business, unless any shareholder has any question to ask.

Mr. OXENHAM: May I ask one question—that is, what is the nature of the outside business that the Company is doing, and which you mentioned?

Mr. SHUTER: We have a large business in gutta-percha at our works in Wharf-road, City-road.

Mr. OXENHAM: I have not often attended these meetings, so I was not exactly aware what the other business was.

The CHAIRMAN: It is a very fine business, and there are large premises for it.

Mr. HEWAT: It only remains for the shareholders, I think, to propose a vote of thanks to you for the information you have given us. I hope the year's accounts will end satisfactorily.

The motion was unanimously agreed to.

The CHAIRMAN: The fewer questions that are asked and the greater the confidence between the shareholders and the Directors the better it will be for the interests of the Company. It is our strength that there should be no misrepresentations in regard to our affairs.

The proceedings then terminated.

London Tramways Company (Limited).

At the general meeting of this Company held last Monday at the offices in Camberwell New-road (Mr. David P. Sellar presiding),

Mr. HENRY C. CLEMENTS advocated the adoption of electric cars in substitution for horse cars. He stated that he had had numerous communications with shareholders, and all of those who had written to him approved the proposed change. He had just heard that the use of electric cars on the North Metropolitan Tramways was not a success, but he did not believe it. He had ridden on them several times, and had made inquiries both from the drivers and conductors, who had told him that they were perfectly safe. Moreover, there was the City and South London Company, and was not the use of electric cars on that system a success? ("No, no.") Had they discontinued them, then?

The CHAIRMAN: They run in a hole; we run in the streets.

Mr. CLEMENTS, continuing, said that he believed that ten different railway companies had lately applied for Acts of Parliament, and in all their Bills they had asked for authority to use other mechanical power. He maintained that the use of electricity on tramway cars was not a failure, and he proposed a resolution setting out—

"*That the time had arrived when it would be much to the interest of the shareholders that there should be no unnecessary delay in substituting electric cars for horse cars.*"

On behalf of the 110 shareholders who had sent him their proxies, he suggested that they should try one part of the system first—say, the Peckham line, and see how the arrangement worked. He did not advocate that electric cars should be run as an experiment, because there was no experiment about it; but he wanted the accounts to be kept separate, and for the matter to be in the hands of half-a dozen of the shareholders, to see that everything was carried out properly. He knew of a gas engine at the present time which would make electricity sufficient for any two of the Company's cars to run continuously, and the expense of this gas engine was 18s. a week. Many of the shareholders approved of his proposal. He had heard from two electrical companies—one of which supplied the North Metropolitan Company—that the cost of electricity, with everything connected with it, would be such that in 1891 this Company would have saved £100,000 from having had electric power instead of horse-power.

The CHAIRMAN, in reply, stated that the Glasgow Tramways were to be taken over by the Glasgow Corporation in two or three years. The Corporation had stated that the cheapest form of traction was electricity, which they endeavoured to obtain, but subsequently they decided to continue the use of horses. The whole of the London Tramways Company's tramways would have to be relaid before they could run electric cars; and they would also have to go to Parliament for powers to use electricity. In America there was not an electrical tramway running through the means of an accumulator. The Company (he said) ran one car down the Peckham-road every minute, and if they used electricity, and one of the cars got out of order, the whole of the line would be blocked.

The resolution was seconded, but was declared lost.

Eastern Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended 31st March last, to be presented to the fortieth half-yearly ordinary general meeting, to be held at Winchester House, E.C., on Friday next, the 22nd inst., at one o'clock:—

The revenue for the six months ended the 31st March amounted to £382,207. 11s. 4d., from which are deducted £105,820. 13s. for the ordinary expenses and £53,515. 5s. 1d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £2,970. 17s. 6d. for income tax, there remains a balance of £219,900. 15s. 9d., to which is added £57,509. 7s. 1d., brought from the preceding half-year, making a total available balance of £277,410. 2s. 10d. From this amount there have been paid:—

	£	s.	d.
Interest on Debentures and Debenture Stock	22,274	13	3
Dividend on Preference Shares.....	20,474	2	0
An interim dividend of 1¼ per cent. on the ordinary shares	50,000	0	0
	£98,748	15	3

Leaving a balance of £178,661. 7s. 7d., from which £68,000 has been carried to general reserve.

The Directors now recommend the declaration of a final dividend for the year ended March 31, 1892, of 2s. 6d. per share and a bonus of 3s. per share, amounting together to £110,000, both payable on the 22nd inst., free of income-tax, and making, with the three previous payments on account, a total distribution of 13s. per share, or 6½ per cent. for the year on the ordinary shares. The balance of £661. 7s. 7d. shown at the foot of the revenue account is proposed to be carried forward to the next half-year.

The revenue includes £32,791. 12s. dividends and bonus for the half-year upon the Company's investments in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

The shareholders having at the last general meeting approved the principle of establishing a staff pension fund, your Directors have had the details worked out by experienced actuaries, and a scheme will be submitted to the meeting for dealing with the matter, together with a formal resolution empowering the Directors to carry out the necessary arrangements.

Electrical Power Storage Company (Limited).

The following is the report of the Directors of this Company, to be presented to the shareholders at the third ordinary general meeting, to be held on Wednesday, July 20th, at 4, Great Winchester-street, London, E.C., at 12:30 p.m.:—

The gross profit and other sums receivable amount to £37,045. 12s. 2d. The Directors have made provision for maintenance of buildings, plant and tools, and depreciation, by writing off the sum of £1,401. 6s. 1d. The net profit, after payment of general expenses, management, &c., is £5,763 11s. 9d., out of which the Directors propose to pay a dividend of 6 per cent. on the paid-up capital of the Company. This will absorb £5,017. 4s. 2d., and the remainder, viz., £746. 7s. 7d., the Directors propose to carry forward to next account.

The Directors have during the past year completed the necessary arrangements for changing the name of the Company from the Foreign and Colonial Electrical Power Storage Company (Limited) to Electrical Power Storage Company (Limited), thus restoring to the Company the prestige of the old E.P.S. name.

During the past twelve months the Company has acquired a lease of the storage battery manufacturing business previously carried on by the Electric Construction Corporation at Millwall and Wolverhampton, and included in this lease is the use of the plant, machinery, and, for a period of three years, of the stock existing at Millwall, where the business is now carried on.

The accounts have been made up to May 31, 1892, as at that date the lease of the manufacturing business from the Electric Construction Corporation (Limited) had been in existence twelve months. The shareholders will note with satisfaction from the profit above mentioned that the business of the Company exhibits marked vitality.

The patents of the Company have been upheld abroad by legal decisions, which should have a beneficial effect upon the general business of the Company.

The utility of secondary batteries for the work of central electric lighting stations, and the absolute necessity of such apparatus in private light-

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ing installations being now generally admitted, the Directors are devoting attention to the commercial application of the secondary battery to electric traction. Very considerable success has attended the use of the Company's batteries for electric launch work. Some thousands of cells are, and have been, in use for this purpose during the past five years. Much activity exists among the various engineers, who are endeavouring to develop commercial methods of electrically propelling tramcars, omnibuses, and other vehicles, and the Company is in a position to profit by the successful result of their labours.

The Directors are pleased to report that at the Crystal Palace Electrical Exhibition, 1892, the Company received the only gold medal for storage batteries.

The retiring Directors are Mr. Frederick Green and Mr. James Pender, who, being eligible, offer themselves for re-election. The auditors, Messrs. Broads, Paterson and Co., also offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, *pages 308-322, &c., &c.*]

HENRY WIGGIN AND CO. (LIMITED).—Registered with a capital of £160,000, in £10 shares, to carry into effect an agreement for the acquisition of the business now carried on by Messrs. Henry Wiggin and Co., of Birmingham and Smethwick, and of Thomas Adkins and Co., of Smethwick, as refiners of nickel and cobalt, manufacturers of German silver, red lead, &c , and as metallurgists and manufacturing chemists, and to carry on and extend the said businesses in all their respective branches.

HEPBURN AND GALE (LIMITED).—Registered with a capital of £60,000, in £10 shares, to adopt and carry into effect an agreement, made June 8th, between Hepburn and Gale (Limited), of the one part, and W. A. Posnett, on behalf of this Company, of the other part ; generally to carry on business as tanners, curriers, leather merchants, manufacturers of eather belting, hose pipes, and all leather articles for mechanical purposes

J. C. HOWELL (LIMITED).—This Company was registered on the 9th inst., with a capital of £25,000, in £5 shares. The objects are to acquire all or part of the businesses, goodwill, machinery, rights, privileges, and other property of Mr. John Charles Howell, of New Dock, Llanelly, and of 24, Queen Victoria-street, London, E.C., electric light engineer ; to acquire any letters patent relating to inventions for the production and supply of light, heat, or power, by means of electricity, magnetism, or other power ; to generate, accumulate, and distribute electricity, and to contract for the lighting and heating by electricity of any public or private property. The subscribers are (each with one share) John C. Howell, Llanelly (electric light engineer); W. M. Meredith, Dorking (engineer); H. C. Cornish, Llanelly ; T. H. Lewin, Parkhurst, Dorking ; Percy C. Scrutton, 24, Queen Victoria-street, E.C. (electrical engineer) ; H. de B. Porter, The Hollies, Finchley, N. ; W. Eacott, 29, Powell-road, Clapton, N.E. The number of Directors is not to be less than three nor more than seven, the first being John C. Howell and W. M. Meredith, who are Managing Directors for a period of five years from the date of the incorporation of the Company.

JAMES SIMPSON AND CO. (LIMITED).—Registered with a capital of £250,000, in £10 shares, to acquire the undertaking, property, and assets, of James Simpson and Co. (Limited), registered on December 19, 1885, and to carry on at the engine works, Grosvenor-road, Pimlico, and elsewhere, the business of manufacturing engineers, mechanical and electrical engineers, machine and engineering tool makers, boiler makers, iron founders, brass founders, metal workers, &c.

LITHANODE AND GENERAL ELECTRIC COMPANY (LIMITED).—This Company was registered on the 8th inst, with a capital of £100,000, in £1 shares. The objects are to adopt and carry into effect an agreement to be made between the Mining and General Electric Lamp Company (Limited) and its liquidator of the one part and this Company of the other part ; to carry on the business of an electric, gas and other light company ; to construct, lay down, establish, fix and carry out all necessary mains, reservoirs, cables, wires, lines, accumulators, lamps, machinery and works ; to manufacture, generate, accumulate, distribute and supply electricity, gas, &c. ; and to carry on business as electricians, mechanical engineers, gas engineers, lamp manufacturers, manufacturing chemists, contractors for public and private works, suppliers of electricity and manufacturers of electrical and scientific apparatus. The subscribers are (with one share each) J. E. Huxtable, 14, St. Helen's-place, E.C. ; C. H. B. Ince, 102, Alexandra-road, South Hampstead ; L. Mossop, B.A., 7, Camball-road, Putney ; C. R. Pearson, 2, Balfour-terrace, High-road, Leytonstone ; J. E. Wood, 10, Placquett road, East Dulwich, S.E. ; A. C. Crane, 3, Wood-lane, Highgate, N. ; J. A Gedge, 14, Abbeville-road South, Clapham Park, S.W. The number of Directors is not to be less than three nor more than nine, the first to be appointed by the above-named subscribers.

RICHMOND (SURREY) ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This Company was registered on the 8th inst., with a capital of £50,000, in £5 shares. The objects are to carry out the terms of the Richmond (Surrey) Electric Lighting Order, 1883, in so far as they may be capable of being carried out in accordance with and subject to the provisions of a contract dated December 8th, 1891, and made between the Corporation of the Borough of Richmond of the one part, and Latimer Clark, Muirhead and Co. (Limited) of the other part ; to enter into and carry into effect the agreement with the said Latimer Clark, Muirhead and Co (Limited), mentioned in Clause 3 of the Articles of Association of the Company, whereby the benefit of the said contract of December 8, 1891, is agreed to be assigned to the Company, and to carry on throughout the Municipal Borough of Richmond and any further extensions thereof, the business of an electric light and power company for any public and private purposes, as defined by the Electric Lighting Act, 1882, and subject to the provisions of the said Act and the Electric Lighting Act, 1888. The subscribers are (with one share each) William E. Grigsby, LL.D., B.C.L., M.A., 7, King's Bench-walk, Temple ; Sir Edward Hertslet, C.B., Bellevue House, Richmond ; Douglas B. Hall Heywood, Maidenhead, Berks ; Robert L. Kidd, Kewfoot-road, Richmond ; J. Soares, Richmond ; Francis B. Alston, 69, Eccleston-square ; Edward C. Curtis, 15, Cranley-place, S.W. The number of Directors is not to be less than three nor more than seven, the first to be appointed by the above-named signatories.

HERSEY BROTHERS (LIMITED).—This Company was registered on July 8, 1892, with a capital of £5,000, divided into 250 £8 per cent. preference and 250 ordinary shares of £10 each, to acquire, take over as a going concern, and carry on the business of a gas, water, electric, and ventilation engineer, now carried on by George W. Hersey, under the style or firm of Hersey Brothers, at 70, Berners-street, Oxford-street, W.

THOMAS PIGGOTT AND CO. (LIMITED).—Capital £90,000, in £10 shares, to acquire, take over as a going concern, and carry on the business of gas, water, mechanical, and electrical engineers, steel, iron, and brass founders, metal workers, millwrights, &c., belonging to, and carried on by, Messrs. Thomas Piggott and Co.

CALLENDER'S BITUMEN, TELEGRAPH, AND WATERPROOF COMPANY (LIMITED).—The annual return of this Company, made up to May 31st, was filed on June 10th. The Company was registered on April 19, 1882, with a capital of £40,000, in £10 shares, and in 1891 the capital was raised to £80,000 by the addition of 4,000 new shares of £10 each. At the time of making up, 6,316 shares were taken up, of which 3,000 had been issued as fully paid, as part payment of the purchase consideration ; upon the remaining 3,316 the full amount had been called, resulting in the payment of £29,371, and leaving £3,789 in arrears.

CUTTRISS, WALLIS AND COMPANY (LIMITED).—The annual return of this Company, made up to June 16th, was filed on the 22nd. The nominal capital is £10,000, in £5 shares. 736 shares have been taken up, of which 420 have been issued as fully paid. Upon the remaining 316 shares a call of £4 per share has been paid.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The annual return of this Company, made up to June 23rd, was filed on the 8th inst. Out of a nominal capital of £200,000, divided into 39,900 ordinary and 100 founders' shares of £5 each, 20,000 ordinary and 100 founders' shares have been taken up, Upon the ordinary shares a call of £1 per share has been made, and upon the founders' shares the full amount has been called, resulting in the payment of £20,500.

ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY (LIMITED).—The annual return of this Company, made up to June 23rd, was filed on the 1st inst. Out of a nominal capital of £200,000 in £2 shares, 75,000 shares have been taken up, of which 25,000 have been issued as fully-paid as part payment of the purchase consideration. Upon the remaining 50,000 shares the full amount has been called, resulting in the payment of £95,395. 5s., and leaving £4,604. 15s. unpaid.

PIONEER TELEPHONE COMPANY (LIMITED).—The statutory return of this Company, made up to June 25th, was filed on the 4th inst. 6,000 of the 10,000 £10 shares have been taken up, and the full amount called. The calls paid amount to £59,910, and unpaid to £90.

CITY NOTES, &c.

BABCOCK AND WILCOX (LIMITED).—The Stock Exchange Committee have appointed this day (Friday) the special settling day in this Company's Six per Cent. Cumulative Preference Shares Nos. 3,334 to 10,000, and Ordinary Shares Nos. 4,667 to 14,000, and have ordered these securities to be quoted in the official list.

CALLS DUE.—*July 15th :* £2. 10s. final on SOUTH AMERICAN CABLE COMPANY'S 20,000 £10 shares.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 10th were £733, as against £692 for the corresponding period of last year, being an increase of £41. The total receipts to date, from January 1st last amount to £21,210, against £19,917 in the corresponding period of 1891, being an increase of £1,293.

DIVIDENDS DUE.—*July 23rd :* EASTERN TELEGRAPH COMPANY, LIMITED, 2s. 6d. per share for quarter and 3s. bonus. *July 31st :* EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY, LIMITED, 7 per cent. for year ending June 30th, 7 per cent. arrears to June 30, 1887, and 4 per cent. arrears to June 30, 1888. *Not dated :* NATIONAL TELEPHONE COMPANY, LIMITED, 7 per cent. for year ended April 30th. *July 22nd :* WEST AFRICAN TELEGRAPH COMPANY, LIMITED, 5s. per share. *Not dated :* WESTERN UNION TELEGRAPH COMPANY, dividend for quarter at the rate of 5 per cent. per annum.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 8, 1892, after deducting 17 per

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cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,790.

CRICKET.—EASTERN TELEGRAPH COMPANY (LIMITED) v. KENNETH ANDERSON AND COMPANY.—This annual match was played on Saturday last at Neasden, and resulted in a victory for the Easterns. K. A. and Co. went in first, and put together 64 runs. The Easterns were more successful, and made 166 runs. Mr. Prosser, the Eastern Company's superintendent at Perim, contributed 66, winning the bat presented for the highest score. With only 35 minutes' play, K. A. and Co. started their second innings, and put together 100 runs without the loss of a wicket, when time was called. The ball for the best bowling average went to Mr. Burke (Eastern). Score:—

K. A. AND CO.—F. Spencer, b J. G. Macmillan, 26, not out, 26; G. C. Hawes, c Hardie, b Burke, 0; — Beaton, b Burke, 14; A. Jack (Capt.), c Draper, b Macmillan, 9, not out, 74; H. Gurney, b Burke, 1; Kenneth Anderson, b Burke, 5; A. Gardner, b J. G. Macmillan, 1; Stuart Anderson, not out, 4; J. White, c Wells, b Burke, 0; Kenneth Anderson, Jun., c Hardie, b Burke, 0; J. Strudwick, run out, 0; extras, 4; totals, 64, and (for no wicket) 100.

EASTERNS.—H. O. Wells, b A. Jack, 9; A. W. Prosser, lbw b Gardner, 56; G. C. Jack, b A. Jack, 45; A. R. Hardie, b A. Jack, 0; George Draper (Capt.), run out, 0; J. G. Macmillan, b A. Jack, 31; H. J. Burke, c and b A. Jack, 16; A. Penny, not out, 5; T. Richardson, st Beaton, b A. Jack, 0; A. G. Macmillan, b Kenneth Anderson, 0; A. W. Donaldson, c A. Jack, b Kenneth Anderson, 0; extras, 6; total, 166.

COMPANIES' SHARE LIST.

PRESENT AMOUNT	AMOUNT OF SHARE.	LAST DIVIDEND.	NAME.	PREVIOUS WEEK'S PRICE, JULY 6.	PRICE WEDNESDAY, JULY 13.	RATE PER CENT. YIELDED. £ s. d.	DIVIDEND DUE.	BUSINESS DONE DURING WEEK ENDING JULY 13. Highest.	Lowest.
			TELEGRAPHS						
£1,247,720	Stock	12 6	Anglo-American	43 49	48 49	5 8 1	Jan., Apr., July Oct	..	..
£2,876,140	Stock	25/0	Do. Preferred	88 89	88 89	5 18 0	" "	88½	87½
£2,876,140	Stock	5/0	Do. Deferred	10½ 11½	.. ..	..	" "	10½	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures xd	99 103	99 103	3 17 8	January and July	102	..
130,000	£10	3/0	Brazilian Submarine xd	10½ 10¾	10½ 10¾	6 10 3	Mar., June, Oct., Dec.	10½	10½
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906) xd	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	155 160	155 160	4 7 6	Jan., Apr., July, Oct.	157	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	11¾	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,981	5	1/7	Direct Spanish (£4 paid)	3½ 3¾	3½ 3¾	4 16 9	April and October	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11¾ 11¾	11¾ 11¾	6 0 8	Jan., Apr., July, Oct	11¾	11⅞
400,000	10	2/6	Eastern	14¾ 15	14¼ 15⅛	4 5 11	" "	15⅛	14¾
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15¾	15⅛ 16	3 15 0	" "	15¼	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	111	109½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	110	..
250,000	10	6/6	Eastern Extension	15 15½	15 15½	4 11 10	Jan., Apr., July, Oct.	15¼	15
£200,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900 xd	101 104	102 105	4 15 3	January and July	103¾	..
£125,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900 xd	100 103	101 104	4 16 2	" "	101⅛	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102 105	102 105	3 16 2	February & August	..	..
180,227	10	2 6	Globe Telegraph and Trust	10½ 10⅝	10½ 10⅝	5 1 2	Jan., Apr., July, Oct	10¾	10⅝
120,042	10	6%	Do. 6 per Cent. Preference	15⅜ 15⅝	15⅜ 15⅝	3 18 1	" "	15⅝	15⅜
150,000	10	5 0	Great Northern xd	18½ 19	18½ 19	4 9 6	Jan., April, and July	18⅞	18½
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	103 109	106 109	4 11 9	March & September	..	..
17,000	25	1¾	Indo-European	40 42	40 42	5 19 1	May and November	..	..
38,348	10	4,0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
10,502	8	8 0	Reuter's	7 8	7 8	5 0 0	April and October	..	..
2,861	£100 Cert.	£1½	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	6 8	6 8	5 0 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	102½	102½
80,000	10	2,0	West Coast of America	3⅞ 4½	3⅞ 4½	5 11 1	January and July	3⅞	3⅞
£150,000	100	8%	Do. Debentures 8% 1902 xd	101 105	101 105	7 12 5	June and December	..	..
88,231	10	Cl.	West India and Panama	1¼ 1⅝	1¼ 1⅝	..	" "	..	..
34,568	10	6%	Do. 6 per Cent. 1st Preference	9½ 10	9½ 10	6 0 0	May and November	..	9½
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
64 242	15	6,0	Western and Brazilian	8¾ 9½	8¾ 9½	6 9 7	" "	..	8¾
33,129	7½	1/3	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 7	" "	..	..
33,129	7½	4 0	Do. 5 per Cent. Deferred	2¾ 3¼	.. ..	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105 108	105 108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105 108	105 108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£178,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
234,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ¼	⅛ ¼	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	7/16 ½	7/16 ½	6 5 0	Yearly	..	..
498,984	5	2/6	National	4½ 5⅛	4½ 5⅛	5 17 1	June and December	5⅛	4¾
1 ,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13⅜ 14½	13⅜ 14½	4 4 3	" "	..	..
1 ,000	10	6%	Do 6% Cumulative 2nd Pref.	12⅞ 13½	12⅞ 13½	4 10 7	" "	13½	13½
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.) xd	108 110	108 110	4 1 10	January and July	109½	108½
58,000	5	1/0	United River Plate	1½ 2¼	1½ 2¼	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock xd	85 95	85 95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
20,152	£10	..	City of London Electric Lighting (fully paid)	10 10½	9½ 10½	..	—	10¾	10
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	..	..
8,332	£5	..	House to House electric	2½ 3½	2½ 3½	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½ 6	5 5½	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 6	5½ 5¾	..	January and July	..	..
20,000	£5	4½%	Liverpool Electric Supply (£3 10s paid)	3 7/16 3 9/16	3 7/16 3 9/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	¾ 1¼	¾ 1¼	..	..	..	..
48,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7	6½ 7	..	—	6¾	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5	4 5	—	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8 8½	7¾ 8½	—	..	8⅞	8½
7,900	£5	7%	Do. 7% Preference	7¾ 8½	8 8½	..	..	..	..
42,868	5	..	Westminster Electric Supply (fully paid)	6½ 6¾	6½ 6¾	..	..	6½	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	2	1/0	Brush Electrical Engineering	2½ 3½	2½ 3½	..	..	3½	2½
69,996	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2⅜	2⅛
20,000	5	2/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5½ 6	5 16 8	January and July	..	..
12,149	5	17%	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	12,0	Electric Construction	5 5½	4½ 5	..	—	6	4½
70,000	2	10/0	Elmore's Patent Copper Depositing	2½ 2⅝	2 2½	..	—	2⅝	2½
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
60,000	10	15/0	India Rubber, Gutta Percha & c., Works	20½ 21½	21 22	5 12 7	February & August	21¾	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	6½ 7½	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼ 7/16	¼ 7/16	..	..	..	..
78,949	5	2,0½	Swan United (£3. 10s. paid)	3½ 3¾	3 3¼	11 0 0	May and November	3⅜	3⅛
27,350	12	36,0	Telegraph Construction and Maintenance	45 47	45 47	5 2 1	March and July	46	45½
150,000	100	5%	Do. 5 per Cent. Bonds, red 1894 xd	103 106	103 106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅛ ¼	⅛ ¼	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2⅛ 3	2⅛ 3	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
80,000	£10	—	City and South London Railway	2⅛ 2⅜	2⅛ —	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

The Medical Battery Company (under which title the Harness "electropathic" belts are made) has attempted to recover five guineas from an unfortunate man who submitted himself to them for treatment. Medical evidence showed that he was suffering from hernia; but a furniture salesman employed by the Battery Company to look after such patients did not recognise it, and "fitted" him with a belt which chafed the skin and caused excruciating pain. Mr. Gatehouse, to whom we are indebted for the report of which an abstract will be found in another column, gave evidence about the non-electrical properties of the belt. In the result, the Company's application was dismissed, and the counter-claim for return of part payment was allowed with costs. It is a pity the case did not turn upon the "electrical properties" of this so-called "electric" belt. We yet hope to learn that the subject of these wretched impostures may lead to a successful Treasury prosecution.

It is worthy of note that although the wiring at the Crystal Palace Electrical Exhibition was of a temporary character, and unusually high voltages were employed, there was not a single alarm of fire, a result of which Mr. Heaphy is naturally proud.

The Corporation of Brighton have issued a circular containing a number of useful suggestions and hints about the use of electric light. The prices are a good deal less than might have been expected, the charge per Board of Trade unit being 7d.; and the cost of wiring, "inclusive of simple fittings," is put at 20s. to 30s. per lamp. The Corporation does not undertake wiring, but recommends local firms, and offers the advice and assistance of their engineer. The importance of sufficient wiring is insisted upon; and it is recommended that a drop of only 1 per cent. should be allowed. The uniformity of pressure maintained by the Corporation is alluded to several times in this circular; and we hope that they have got over the difficulty of the insufficient size of their mains, which was threatened some little time ago. It is easy to read between the lines of this pamphlet a reference or two to a rival supply; and we find a claim that "arc lamps supplied from the Corporation continuous-current mains produce nearly 100 per cent. more light than those from the alternating-current system for the same amount of electricity charged;" and "the electricity consumed by them can be exactly measured, which cannot be done by any known meter of the lamps which are supplied by alternating currents."

At the same time that they resolved to spend some £26,000 on electric lighting, the Corporation of Blackpool, as will be seen in our Notes column, also decided to put the post of supervisor of this large expenditure up to tender; that is to say, the Town Clerk was directed to advertise for a resident electrical engineer, "applicants to state amount of salary required." We have no doubt that this step will result in an immediate relief of the rates, if only the cast-iron rule of the acceptance of the lowest tender be adhered to. Electrical engineers are a glut in the market, and it is by no means difficult to imagine some of them going so far as to offer the Corporation a good round sum in hard cash for the privilege of gaining a little practical experience. The title of the municipal electrical engineer has up to the present been more imposing than his emoluments, and if the example set by the Blackpool Corporation should prove contagious, the salary curve will rapidly tend to zero, and may ultimately become a negative quantity.

The eagle eye of Colonel Makins, of the Gas Light and Coke Company, has discovered an ambiguous sentence in the remarks appended to the tables relating to electrical supply, which appeared in our issue of July 8th; and our contemporary, the *Journal of Gas Lighting*, which had published the information without detecting the ambiguity, has consequently been moved to attack us somewhat in the age-of-chivalry-is-past vein.

Endeavouring to arrive at a rough approximation of the output of the Gas Light and Coke Company, as compared with that of *all* the statutory electricity supply companies in London, we concluded as follows:—

"The output of the Gas Light and Coke Company for the half-year ending December 31, 1891, was 10,000,000,000 cubic feet; so the whole of the electric lighting by supply companies corresponds at present to only 6·64 per cent. of the output of this one gas company."

For perfect lucidity, we readily admit that the qualification "half-year's" should, in the latter portion of the sentence, have preceded the word "output"; but the context exonerates us from the absurd imputation of an intention

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to mislead, and common arithmetic shows that there is no "ridiculous blunder." The reason why the half-yearly output was chosen at all was simply that we only happened to have those figures by us at the time, and did not care to make any assumption as to the remaining six months of the year.

We are further reproached with "coolly assuming" that an 8-c.p. glow-lamp is equivalent to "a gas burner consuming 5 cubic feet of gas per hour, which, by Act of Parliament, must give a light of 16 candles." To this we can only reply that it is as impossible to make an ordinary 5ft. burner give 16 candles as it is to make a man sober by Act of Parliament.

In order to get 16 candles out of 5 cubic feet of gas it is necessary to use a burner specially made for this purpose, and costing ten shillings. In speaking of the quality of gas, the use of this burner is always recognised, and London gas is kept as nearly as possible to this standard. But when we speak of the light yielded by gas burners that is quite another matter. It ought to be better known that new Sugg and Bray burners of the ordinary make hardly give two candles per cubic foot, and often less than $1\frac{1}{2}$; and we undertake to say that the average of ordinary burners in any average house in London, including flaring and dirt, is not greater than $1\frac{1}{2}$ candles per cubic foot.

Our contemporary says that "it has, moreover, been admitted by electricians over and over again, that for ordinary all-round lighting a so-called 16-candle incandescent lamp is not so effective as a 5-cubic feet gas burner." We have nothing whatever to do with the admissions of electricians. The 5-foot 16-candle convention is in our opinion more deceptive than the 2,000 candle-power arc lamp anomaly, and is less excusable by reason of the greater ease of the photometry. We speak with greater confidence since there is only one make of glow lamp in use in this country, and in electric lighting there is no special contrivance such as the "London Argand," costing from eight to thirty times the price, and giving twice as much light as the ordinary make.

No one but a crammer will disagree with "W. M. M." that the blind use of imperfectly understood symbols is fatal to progress, but that points to the need of a clearer comprehension of these symbols. Mr. Williams has set himself the task of attempting to rationalise the dimensional formulæ which have for so long been obscured by conventions and arbitrary assumptions; and "W. M. M." explains that he does not wish to suppress the whole theory of dimensions of fundamental units, but to use these dimensions merely for the purpose of obtaining numerical relations between quantities. If this can be done by a process of reasoning which can be clearly expressed, there is little to object to in our correspondent's argument. If it cannot, the statements quoted by "W. M. M." are opposed to such a limited meaning being given to units. We do not think a merely numerical interpretation is sufficient, for we have not yet seen in any text-book a satisfactory description of the method of obtaining the number which represents in electrostatic units a given quantity expressed in the electromagnetic system.

The statement that a cubic foot of water weighs about 1,000 ounces may be regarded as an illustration of a relation between units; for it is equivalent to saying that the amount of water contained in a cubic foot is about 1,000 times as great as the amount of water which weighs one ounce. In order to express a quantity of water in terms of one of these units, when it has been given in terms of the other, we have to use the numerical relation, 1,000. But this number does not express the ratio of a cubic foot to a pound, because in the first place such a relation is unintelligible until a specific substance is mentioned, and in the second place because it is only true for water. A relation between units is meaningless, unless the unit is understood to refer to something more than the mere measuring vessel, or other standard determining the magnitude of the unit; and it appears to us that to look upon dimensions merely from a numerical point of view will only increase the obscurity of the subject.

English "as she is writ" in the instructions to engineers for the use of Faber's slide rule is a fearful product. "Let it be supposed," says the book of instructions, "that a mountain river carries per second a volume of 1·64 cubic m., and that it possesses at a given place an available fall of 38·2 m.; what is the *force* obtainable at this place, *expressed in horse power*?" Nor is the situation improved by the information that "the unit of labour is the labour performed in a distance of 1 m. by a *force of* 1 *kilogramme per second*." We commend this derangement of epitaphs to our valued correspondent "W. M. M." and to his friends who think the study of the dimensions of units of no use. "A support lathe whose leading spindle has a rise of $\frac{1}{2}$in." appears to be pidgeon English for a screw-cutting lathe having a principal screw of $\frac{1}{2}$in. pitch. Considering, however, the fame of the eminent Bavarian house from which the instructions issue, we imagine that these instructions are really not primarily intended for engineers, but rather for persons who need a slide rule to perform such complicated arithmetical exercises as the following: "the price of one gross of *leadpencils* (144 pieces) is Mark 10,80; what is the cost of one?" But we fear that not even a study of dimensions will enable any calculator—with or without a slide rule—to deduce the cost from the selling price.

A gentleman named Smith has been rash enough to try to turn the phonograph to some useful purpose. Perhaps he was not aware that fate has decreed that this toy shall not be sold in this country. For his sins he soon found himself in the Law Courts; but, rash man that he was, he pushed on after obvious defeat to further discomfiture in the Court of Appeal. Why will men fight with the gods, and Mr. Smith with Destiny?

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The Liverpool Overhead Railway.—Trains will be run on this line in October next.

Bray.—The electric lighting of Bray has become a *fait accompli*, and the system will be turned over to the Township Commissioners in the course of a few days.

Dover.—At a recent special meeting of the Town Council, the proposals of the Brush Company with regard to the lighting of the town were agreed to.

Chicago Exhibition.—All the Exhibition buildings, except two, are practically finished. The Westinghouse generators are to be 10,000 lighters, with one 20,000 light machine.

The City of London Electric Lighting Company.—The Board of this Company announce that the supply of current will be available, both day and night, on and after August 1.

The London-Paris Telephone.—A call office has been opened in connection with the London-Paris telephone at the West Strand Telegraph Office, Charing-cross. The office will be open day and night.

Electric Traction in Belgium.—The first electric tramway in Belgium, namely, that at Liège, is now being constructed by Van den Kerchove, of Ghent. Five cars, with 20-H.P. single-reduction 500-volt motors, are to be run.

The London Electric Supply Corporation.—The standard charge for current by this Company has been reduced to 7d. per Board of Trade unit. This change will take effect as from the commencement of the current quarter.

Winter Sessions.—Electrical Engineering courses will be begun early in October at University College, Bristol, and at the University College of North Wales (Bangor). For further particulars see our advertisement columns.

The Gresham University.—The Royal Commission inquiring into the granting of a Charter to the Gresham University is now sitting. The Bishop of London and the Rev. H. Wace, D.D., representing King's College, London, have given evidence in favour of granting the charter.

Bournemouth.—There was recently a slight explosion in one of the junction boxes of the Bournemouth and District Electric Supply Company. The damage done was unimportant, two of the fuses having merely shifted from their original position. The fuses were not melted.

Royal Institution.—At the general monthly meeting of this Institution, held on Monday, July 4th, the special thanks of the members were returned for the following donations:—Prof. Dewar (grant from Royal Society), £300; Ludwig Mond, Esq., £120; Hugo Müller, Esq., £50, for carrying on investigations on liquid oxygen.

Atmospheric Electricity.—A curious effect of the abnormal weather, says the *Indian Engineer*, was observed the other day on the Bengal-Nagpur telegraph system. It was found that the natural current of electricity prevailing was much greater than the artificial; so much so, that measuring the one numerically by four the other was represented by nine.

The Great Northern and City Railway.—At a recent public meeting resolutions were passed in favour of obtaining memorials, and the co-operation of the Islington Vestry to the end of getting a station erected somewhere in the Upper-street. Petitions were at once signed. It was also decided to send with the Vestry a deputation to the Company.

The Royal Commission on Electrical Communication with Lighthouses and Lightships.—This Commission is now taking evidence. Sir George Nares, Sir Leopold M'Clintock, Mr. F. Bedwell, hydrographer to the Telegraph Construction and Maintenance Company, Mr. Scott, secretary of the Meteorological Council, and Captain Anson, of the Ramsgate Coastguard, have been examined. The Commission has considered in detail the cases of the various lightships and light-vessels around the coast of England, Wales, and Ireland.

The New House of Commons.—Amongst the members of the new House of Commons are several well known to our readers, including Sir John Pender, K.C.M.G., Mr. J. S. Balfour, Hon. W. St. J. F. Brodrick, Mr. E. Boulnois, Mr. W. H. Fisher, Mr. J. W. Phillips, Mr. Sheriff H. S. Foster, Mr. W. Cuthbert Quilter, Mr. E. H. Bayley, and Col. Loyd. Sir G. Elliot, Mr. Hugh Watt, and Mr. Storey-Maskelyne failed to retain their seats; and Mr. James Pender, Mr. Thomas Parker, and Mr. Robert Hammond were also unsuccessful candidates.

Blackpool.—At the last meeting of the Town Council it was decided to lay down an electric lighting plant capable of supplying current for 13,500 8-c.p. incandescent lamps and 165 arc lamps. The estimated capital expenditure is £26,000, and the alternating-current transformer system is to be adopted. The Board of Trade unit will be sold at 6d. It was also decided to appoint a resident electrical engineer, and the Town Clerk and Chairman of the Committee were directed to advertise for one, applicants to state amount of salary required.

Institute of Chemistry.—At the examination in Practical Chemistry for admission to the Institute, held from Monday, 11th, to Friday, 15th inst., 37 candidates presented themselves, of whom the following 19 were successful:—Messrs. E. C. Baly, F. J. Bloomer, A. C. Chapman, J. C. Chorley, F. Dent, F. E. Francis, A. F. Fryer, F. J. Hambly, E. E. Johnson, T. Kendrew, C. Leigh, H. H. Mann, C. H. New, T. H. Norris, W. Orr, N. S. Rudolf, W. D. Sawers, A. E. Wareing, and Miss E. J. Lloyd.

Aluminium.—Towards the end of last year two German chemists, Herren Lubbert and Roscher, announced that aluminium, being attacked by wine, brandy, coffee, tea, &c., was not available for domestic utensils. At the meeting of the Académie des Sciences on June27th last, however, M. Ballaud rehabilitates in some measure the character of the aspersed "national metal." According to this gentleman months of experiment have shown him that aluminium *is* a suitable metal for domestic utensils, air, water, wine, beer, cider, coffee, milk, oil, &c., &c., having less action upon it than upon ordinary metals.

The Electrical Production of Ozone.—One use of ozone, on which Herr Frölich lays special stress in a recent lecture, is the disinfection and sterilisation of water. From recent experiments in the Siemens and Halske laboratory at Berlin, it appears that good results have been attained in producing ozone on a commercial scale by means of the silent electric discharge. An apparatus now at work in the laboratory yields 2·4mg. of ozone per second. Experiments are being made in supplying compressed ozone for technical use; and this has been accomplished with a pressure of nine atmospheres.

The Polyphase Current in France.—According to the *Revue Internationale de l'Electricité*, MM. Guitton and Bertolus, owners of the Oerlikon patents for France, have concluded a 30 years' electric light and power contract with the municipality of Romans. They propose to use a 1,000ft. fall, 17 miles distant from the town, and to employ polyphase currents. The Edison Company of Saint-Etienne also intends to adopt the polyphase system in carrying out the large transmission and distribution of power scheme voted by the Municipality. Near Montpellier a 200-H.P. fall is to drive polyphase dynamos supplying current to a group of villages.

The Electrical Utilisation of Water Power.—The new dam across the Colorado River at Austin, Tex., says the *Engineering and Mining Journal*, will raise the river 60ft. above its low-water mark. Mr. J. T. Fanning, consulting engineer for the city of Austin, states that the river above the dam has a drainage area of 40,000 square miles, and that in times of flood from 200,000 to 250,000 cub. ft. of water per second will pass over the crest of the dam. The dam is being built by the city of Austin to develop power to operate its water and electric lighting plants, and for manufacturing purposes. The dam will be 70ft. high and 1,125ft. long, and will set back water for some 25 miles.

Damage by Lightning.—A violent thunderstorm occurred in the West of England on Saturday last during which houses were struck at Bath, Bristol, Nailsea and Keynsham; a large number of cattle also were killed. At Burnett a fatal accident happened. Two men were at work together in a field, when they were both struck by lightning, one being killed and the other sustaining a severe shock. Three horses which they were working were all hurled to the ground, but not seriously hurt. Last Wednesday week a telegraph post in the suburbs of Gentilly (France) was struck by lightning, and the current was conducted by the

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wires to the local telegraph office, nearly a mile off, and entirely destroyed the telegraphic apparatus in the operating room.

Hove.—The General Purposes Committee reported at the last meeting of the Improvement Commissioners, that they had completed the details with reference to carrying out a scheme for the transfer to a Company of the undertaking created by the Hove Electric Lighting Order, 1890, and presented the deeds. Mr. Woodman briefly reviewed the proceedings of the Electric Lighting Committee, pointing out that the Commissioners had been very carefully safeguarded by their solicitor. A certain portion of the town would have to be lit within sixty days of the signing of the documents, while the whole area would have to be lit with electricity ninety days later. The resolution was carried.

Melbourne.—During a severe storm which occurred in Melbourne some few weeks ago, an insulated overhead wire belonging to the New Australian Electric Light Company came down. Two passers-by set to work to coil the wire up, with the result that one of them was killed and the other severely injured by the 2,000-volt current. Two other persons also received shocks. The wire was finally severed by an axe and the current cut off. At the inquest the coroner said that he did not think that anything had transpired in the evidence to show carelessness or negligence on the part of the company. The jury found that the deceased was accidentally killed by coming in contact with a wire carrying an electric current, in an effort to save another man who was in contact with the same wire. They also found that there was no blame attached to any person in connection with the lighting.

Personal.—Mr. W. B. Esson, who has been for many years with Messrs. Paterson and Cooper, has recently transferred his services to the Gülcher (New) Electric Light and Power Company (Limited), Wellington-road, Battersea, S.W. Mr. Esson's private address is now Thrale Hall, Streatham, S.W. ——Mr. Spagnoletti, the well-known telegraph engineer to the Great Western Railway, will retire from the service of the Company in August on a superannuation allowance. We understand that next month Mr. Spagnoletti will take up the post of Managing Director to the Phonopore Syndicate.——Mr. Christian Gray, of the Silvertown Works, was attacked last Saturday by a lunatic workman, who subsequently committed suicide. Mr. Gray's injuries were, fortunately, not serious.——Dr. Werner Siemens, who was reported early in the week to be lying seriously ill at Hamburg, is, we are glad to learn, now much better. Dr. Siemens is in his seventy-sixth year.

Electric Lighting Notices.—The Hammersmith Vestry has received notices of intention to apply for Provisional Orders from the County of London Electric Lighting Company, and from the Putney and Hammersmith Electric Lighting Company. The Vestry have, however, decided that the necessary steps shall be taken for obtaining a Provisional Order for the electric lighting of the parish; and a special meeting of the Vestry will be held shortly, when a report will be submitted as to the probable cost and most convenient areas to be lighted. Similar notices have been received by the Holborn Board of Works from the County of London (North) Electric Lighting Company, and the Islington and General Electric Supply Company. The Poplar District Board have also received a notice from the County of London Electric Lighting Company. It was resolved that the Works Committee should consider the desirability of the Board itself applying for a Provisional Order.

Continental Strolling Players and the Electric Light.—The use of the electric light, writes an occasional correspondent, is spreading to the most out-of-the-way parts of rural France. Strolling players who travel about giving representations at the various rustic fairs generally include amongst their heterogeneous paraphernalia a small electric lighting plant, the dynamo being usually driven by the traction engine used for hauling the theatrical apparatus from town to town. Arc, not glow lamps, are preferred, and globes are conspicuous by their absence; so that the arcs serve the double purpose of giving light and of death-traps to the myriads of winged insects that are attracted by the beams. Spark protectors would, however, be a boon, as there are at times plentiful showers of hot carbon cinders, which alighting on the spectators beneath give rise to lively complaints. It is interesting to notice this enterprising use of the electric light, and credit is due to the rural blacksmiths who usually manage the plant. The lamps are generally remarkably steady and the brushes properly set.

The Late Mr. Cyrus Field.—The following letter appeared in *The Times* of Monday, over the initials W. H. R.:—

"Sir: Only those who were on board the 'Great Eastern' on August 2, 1865, can have any idea of the 'shock' which the sudden breaking of the Atlantic cable that day gave to those who were interested in the great undertaking that so far had progressed without impediment. Captain (now Sir) James Anderson, Mr. Thomson (now Lord Kelvin), Mr. Varley and the staff of electricians, the Directors, and their friends, all on board the great ship, in fact, were so elated by success and so confident of the accomplishment of the work that the sudden cessation of the strain on the indicator, and the cry that followed, 'The cable is gone!' produced an effect not short of consternation on everyone save one man—Cyrus Field. He rushed up on deck when the fatal announcement reached his ears in the saloon, made his way through the silent despairing group astern who were gazing into the sea in which thousands of fathoms deep their hopes were buried, satisfied himself that the cable was broken beyond remedy, and then, calmly surveying his associates without a trace of agitation on his face, said, 'Well, it's so. I must go down and prepare a new prospectus immediately. This thing is to be done,' and stalked quietly back to his cabin, where he set to work to write out the proposals for a new cable ere the end of the other had well settled down in the Atlantic. You have only done simple justice to the energy and commercial courage of Cyrus Field in your leading article of July 14th. I relate what I saw and heard on the occasion to which you referred."

The Telegraph and the Herring Fishery.—As an instance of the importance of the electric telegraph to our fishing population, the Fishery Board for Scotland, in their annual report, tell us that one Saturday morning a large shoal of herrings was discovered about three to seven miles off the Island of Stronsay by a few boats which happened to be at sea. Having ascertained the position of this shoal the officer wired the particulars, for the fishermen's information, to all the stations in Orkney, and on the Monday following every boat employed in the herring fishery in Orkney was on the fishing ground indicated. The result was that the heaviest fishing ever obtained in one day in Orkney, for the number of boats employed, was landed on the Tuesday. The number of boats fishing was 108, and their total catch was 5,400 crans, valued at £3,240. Consequent upon such a heavy and unexpected fishing, additional coopers, gutters, packers, barrels, and salt had to be immediately sent for from Wick so that the herrings might be cured while they were in a fresh state, and this again was accomplished by means of the telegraph. The officer of Shetland district reports that the telegraphic extensions there are being largely used for fishery purposes, and states that without the wires it would be almost impossible to carry on the herring fishery at those remote stations.

Toynbee Hall Electrical and Chemical Societies.—Last week a *conversazione* was held by the members and friends of these newly-formed societies. After an interesting lecture on "Pigments, Past and Present," Mr. A. P. Laurie, M.A., B.Sc., stated more particularly the object of the societies. The laboratories which were attached were intended only to supplement those already in existence in other parts of London by giving facilities for special work in which members might be engaged during the day. The work of the students would not be cramped by any hard-and-fast rules, and able men would superintend and advise them in their work. He believed there was a great future before them if they only moved in this direction. A small amount of apparatus had already been obtained, and the laboratories would be opened in the autumn. He appealed on behalf of the Committee to the heads of large manufacturing firms in London to give their help, as their small funds would be inadequate to carry on the work efficiently on the basis they had planned. Their initial expenses were already great, and aid from the affluent was sorely needed. Dr. Fison will have charge of the Electrical Department next winter, and will give a course of about 30 lectures dealing more especially with the mathematical calculations connected with the science. Mr. Laurie, we believe, will take charge of the Chemical Department. All communications to be sent to Mr. Jameson, Toynbee Hall, 28, Commercial-street, Whitechapel. The President of these Societies is Mr. Preece, and among the Vice-Presidents are Prof. H. E. Armstrong, Prof. W. C. Roberts-Austen, Prof. Silvanus Thompson, and Mr. G. H. Robertson.

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FEED-WATER HEATERS AND ECONOMISERS.*

Generally speaking, feed-water heaters are vessels for heating the feed by exhaust steam, and economisers utilise the heat of the flue gases for that purpose; by means of the latter the feed-water can be raised to much higher temperatures than with the former.

Feed-Water Heaters.

The maximum temperature to which the feed can be heated by the exhaust steam is always below that at which the exhaust enters the heater. The table below shows the percentage of saving effected for different temperatures of the feed up to 212° F.

Temperature of Feed Water. Degrees.	Heat Units per lb. water evaporated	Percentage increase of heat per lb. of water.
212	212	
200	978	1·2
175	1,003	3·8
150	1,028	6·4
125	1,053	9·0
100	1,078	11·6
75	1,103	14·2
50	1,128	16·8
32	1,146	18·6

From the average results of different experimenters, it has been found that in the heat transmitted per square foot of surface per deg. Fahr. the difference of temperature per hour is as follows:—

	British thermal units per hour. Heating water.	Evaporating water.
Surface of copper pipes	310	1,000
Surface of copper plates	275	530
Surface of cast-iron plates	80	180

These results were obtained when the surfaces of plates were in good condition. The increased rapidity of transmission when evaporating as compared with heating is due to the quicker circulation of the water as it reaches boiling point.

If W = Weight of water in lbs. per hour.
M = Time occupied in heating the water (*i.e.*, the time in which each particle of water passes through the heater) in minutes.
R = Rate of transmission per hour in British thermal units for 1°F. difference of temperature (see above table).
H = Area of heating surface in square feet.
T = Temperature of exhaust steam (Fahr.).
t = Temperature of feed, hot.
t_1 = Temperature of feed, cold.
U = British thermal units used in raising temperature of feed-water, per hour.

Then
$$U = W(t - t_1)$$
$$H = \frac{60\,U}{R\,M\left(T - \frac{t+t_1}{2}\right)}$$
$$M = \frac{60\,U}{R\,H\left(T - \frac{t+t_1}{2}\right)}$$

and if R = 200, T = 228deg., t = 190deg., t = 40deg., M = 10deg.; $H = \frac{W}{25}$, *i.e.*, 1 square foot of surface to every 25lb. of water.

In many heaters as much as 1 square foot to every 15lb. is given. The heat surface should be from 1 to 2 square feet per actual horse-power of boiler (actual horse-power = 30lb. water evaporated per hour).

It is better that the feed-water should be on the outside of the tubes of the heater, so that the sediment or scale may not choke the tubes. If the capacity of the heater be large, so that the water passes through slowly, time is allowed for impurities to be deposited at the bottom of the heater. In fact, for many kinds of feed-waters the heater is an excellent purifier.

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Economisers.

Fuel economisers will heat the feed up to the temperature of evaporation, and therefore give better results than feed heaters. They are, however, not of use unless the temperature of the gases leaving the boiler exceed that required to cause a good draught in the chimney, say 350° F. Owing to the deposit of soot on the heating surface at the end of the boiler flues, it is, perhaps, advisable to have the boiler proportioned to its work, so that the gases leave at a temperature of between 500deg. and 600deg., and to use the balance of the heat available, viz., 500deg. or 600deg. – 350deg. in an economiser such as Green's, where the heating surface is kept clean, and therefore efficient, by means of mechanical scrapers. Again, the difference of temperature between the water in the economiser and flue-gases is greater than that between the flue-gases at the end of the boiler and the water in the boiler, which partly accounts for the greater efficiency of the heating surface of the economiser. There is the additional advantage that the wear and tear of the boiler is greatly reduced by the uniform temperature resulting from the hot feed, and by the deposit of impurities and scale which remain in the economiser and are readily withdrawn from the bottom thereof.

To ascertain the saving by the use of an economiser—

If u_1 = Heat in British thermal units required to raise 1lb. of steam from temperature of cold feed,
u_2 = Heat units used in raising temperature of 1lb. of feed-water from t_2 to t_1.
t = Temperature of steam Fahr.,
t_1 = Temperature of feed (hot), Fahr.,
t_2 = Temperature of feed (cold), Fahr.,
W = Water to be heated in lbs. per hour;
u_1 = $1{,}082 + {\cdot}305\,t - (t_2 - 32)$,
u_2 = $t_1 - t_2$.

Saving per cent. =
$$100\,\frac{u_2}{u_1} = \frac{(t_1 - t_2) \times 100}{1{,}082 + {\cdot}205\,t - (t_2 - 32)}.$$

Total saving per hour = $u_2 \times W$.

Saving per Cent. effected by Economisers when the Feed-Water is Heated to the Temperature of Evaporation.

Temp. F°. of cold feed.	Steam pressure in lbs. above atmosphere. 80	100	150	200
32	24·7	25·8	28	29·6
50	23·2	24·3	26·4	28·2
100	19	20·1	22·2	24

Messrs. Green find that under ordinary working conditions with the hot gases entering the economisers at about 550°F. and leaving at 325°F., each square foot of pipe surface heats 7lb. of water about 150°F. above the temperature at which the water enters the economiser, or transmits rather over 1,000 B.T. units per square foot per hour; or about 4 B.T. units per square foot of surface per 1°F. difference of temperature between inside and outside of tube, which is a very slow rate. If the pipes could be kept absolutely clean, a considerably higher duty might be obtained. At these low temperatures soot forms very rapidly on the surface, and it is due to the efficiency of the means of keeping a clean surface that the best results are obtained. After much experience Messrs. Green have adopted a special form of mechanical scraper, balanced so as to reduce the power required for driving. For a 2,000-sq. ft. economiser a 4-in. engine at 60 revolutions is required, and other sizes in proportion. The mean speed of the scrapers is one yard per minute. They have tried removing soot by means of flame, but this caused unequal expansion and contraction, and so impaired the life of the economiser; also by means of steam, which made a settlement of mud round the bottom of the tubes, tending to corrode them rapidly. Various materials have been employed for making the tubes, including wrought iron, cast iron, steel, brass, and copper, all of which are more or less quickly attacked by the sulphurous fumes in the flue gases; they now find a special mixture of cast iron gives best results; that which they use at present

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has a tenacity 75 per cent. greater than the metal originally used. The tubes are 4in. diameter inside and $\frac{3}{8}$in. thick; each tube is tested to 600lb. per square inch or more, and may be relied on to stand a 200lb. working pressure. The tubes, which are 10ft. long, are set in rows generally four to ten pipes wide, and 8in. from centre to centre of pipe. The width of the economiser between the brick sides = 8in. × number of rows of tubes + 16in. or more, which allows of a space at least 9in. wide along one side for man room. There should be about 3ft. clear space outside of one of the side walls for room in cleaning.

If the feed water is quite cold, say 60°F. or under, there is a liability of sweating on the outside of the tubes by condensation of any vapour in the flue gases. This sets up a rapid corrosion of the tubes, to overcome which it is advisable to connect the hot-water outlet and the suction of the feed-pump by a small pipe, say $\frac{3}{4}$in. in diameter, to slightly raise the temperature of the cold water before entering the economiser.

In ordinary practice the heating surface of the economiser is about 60 per cent. of that of the boilers, and as each tube has 10ft. of surface, number of tubes = boiler heating surface $\times \frac{6}{100}$.

Another rule gives—

1 tube for 3 I.H.P.
„ 70lb. water per hour heated.
„ $2\frac{1}{3}$ actual boiler H.P.

The weight of Green's economiser averages about eight tubes per ton, so that 80 tubes = 10 tons.

Messrs. Babcock and Wilcox make an economiser of wrought-iron tubes lying in an inclined position with a mud drum at the bottom, very much upon the principle of their tubular boiler without the steam drum. The tubes are kept clean by means of steam jets. As the soot falls clear of the tubes, the objection mentioned above does not apply apparently to this type of economiser.

GUTTA-PERCHA.

TLe following is translated from *L'Industrie Electrique*, and is a report of a Paper read before the Société d'Encouragement in June last by M. Jungfleisch. An abstract of a Paper read before the same Society by M. Sérullas appeared in *The Electrician* of May 20th; and in the following issue an article appeared traversing several of M. Sérullas' statements :—

Two months ago M. Sérullas, in giving an account of his expedition to Malaysia to discover the best gutta-percha tree, alluded to a new method of obtaining gutta-percha, but did not enter into details.

Having, in conjunction with M. Damoiseau, investigated the principal constituents of gutta-percha, the author succeeded in obtaining all three of them in a crystallised state, and in ascertaining some precise data with respect to their nature. The variability of commercial samples and the consequent impossibility of reproducing with any degree of certainty the results obtained with any given sample, however, made him postpone publication. The wish to carry on these investigations with gutta-percha, the origin of which was certain, called the author's attention to the results of the French expeditions then at work elucidating the question of our gutta-percha resources, and especially to the results obtained by MM. Seligmann-Lui and Sérullas.

In fact, until quite lately, only vague information had been available with respect to gutta trees. The plants themselves had, indeed, been described with all possible botanic science, but no relation had been established between a given plant and the quality of its gum. The French expeditions fixed attention on these important points. In 1888 M. Sérullas had already sufficiently numerous data to make sure that Hooker's *Isonandra gutta* was the gutta plant *par excellence*.

By all accounts, emanating from this source and from foreign expeditions, the Malay method of working, an essentially destructive one to the *Isonandra* forests, was *the* cause of the approaching exhaustion of these forests, and, therefore, of the exhaustion of a raw product now become indispensable to the electrical industry. The Malays, with their present mode of operation, could only work trees 28 to 30 years old, or shoots of from 14 to 15 years; and the tapping of a tree of 30 only yielded at the most 265 grammes (9½oz.) of raw gutta, which was often mixed with half its weight of foreign matters of no commercial value. Setting to work with more care than the Malays, M. Sérullas had only been able to extract 220 grammes from a 30-year old tree; the gum was, however, purer than that obtained by the natives. M. Sérullas saw a tree 1·2 metres in diameter worked, and it only gave 382 grammes of raw gum.

Such improvident and unproductive processes were very amazing when the enormous consumption was called to mind. M. Trevenen, taking note of the gutta, good or bad, exported from the Malay ports in 1884, arrived at a total of 3,144,847 kilogrammes (3,200 tons), an amount which, according to the data mentioned above, corresponded to the destruction of more than 12 million 30-year old *Isonandra*. However, *Isonandra gutta* were not the only trees cut down, and it might be remarked that similar species gave bad gutta in abundance. But it was nevertheless certain that production tended to rapidly diminish as consumption increased. In 1881 the International Congress of Electricians which met in Paris gave utterance to the fears which this state of things gave rise with regard to the future of the electrical industry. Recently, and on all sides, the big European powers had been moved to safeguard such an important interest by acclimatising the *Isonandra* in their colonies, and by pushing its cultivation. The remote results to be expected from plantations of this kind undertaken 20,000 kilometres from Europe, and on a scale necessarily gigantic if they were to be of any good, would explain the feeble efforts hitherto made. The difficulties encountered by those who endeavoured to bring the European powers to a proper appreciation of the matter made the author doubt the efficacy of the schemes proposed, and led him to try and see if the question could not be attacked in another way.

An examination of the samples brought home by M. Sérullas in 1888 showed that gutta was present in all parts of the plant; the parts other than the trunk contained gutta in amounts apparently very much greater than the trunk itself yielded to the Malays. Was it not possible that the coagulable matter of the latex might accumulate in some part of the plant whence it could be obtained by means more delicate than those employed by the Malays? If by any chance these parts were such that we might separate them from the plant without injuring it, the problem would have made a long step towards solution. Previous unpublished investigations, indeed, left no doubt as to the possibility of finding solvents enabling us to extract gutta from these parts, and to extract it alone. M. Sérullas, who was then setting out again for Indo-China, was good enough to undertake the verification of the numerous hypotheses which a series of trials carried out with this leading idea involved; he also arranged to send home samples gathered under agreed-upon conditions so as to permit of the necessary experiments. Leaving aside mere attempts and suppositions shown to be inaccurate, it only remained, said the author, to point out the facts which these experiments had established.

The solvents which enabled us to extract gutta-percha from vegetable cells were many, but toluene seemed the best in the present case; it dissolved the three principal constituents of gutta-percha, and it did not dissolve in appreciable quantity the substances which accompanied it, with the exception of a little chlorophyll. Comparative tests were made with—(i.) Leaves dried in air, and sent dry; that was to say, exposed to the oxidation of the air. (ii.) Fresh leaves despatched in water, rendered antiseptic, and dried on arrival. (iii.) Dried shoots deprived of their leaves. (iv.) Two-year-old wood, dried and deprived of leaves.

Contrary to anticipation, all these portions supplied much the same amounts of gutta, amounts which were always large. This first result enabled one to predict a favourable issue. It immediately fixed the attention on the part of the plant the most advantageous for treatment. By plucking the leaves, which the plant constantly renewed of itself, the effect upon the development of the plant was reduced to a minimum. The method of extraction was, moreover, a very simple one. The pulverised material was first exhausted by digestion at 100°C., and then by being placed in a solvent, such as toluene. A solution of gutta having a green tint, owing to the presence of a little chlorophyll, was obtained. The direct evaporation of the solvent not being possible without injury to the product, the toluene was carried off by a gentle stream of vapour of water—that was to say, at a maximum temperature of 100°C. For every volume of water evaporated four volumes of toluene were carried off, the gutta remaining. The toluene was completely expelled by prolonging the action of the vapour on the mixture, which was kept at a temperature of 100°C., and in a state of agitation. The yields obtained from the various parts of the plant mentioned above fluctuated between 9 and 10·5 per cent.; they were, therefore, much better than could have been expected.

But it might be asked whether these large yields were not due to the mixture with the gutta of some of the vegetable substances dissolved by the solvent! At first glance the appearance of the resultant product seemed to support this hypothesis; the substance being greenish, whilst the Malay gutta was red. In reality,

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gutta-percha, naturally almost colourless, was tinted in the former instance by traces of chlorophyll, which could be eliminated by appropriate treatment, and in the second instance by fragments of bark and special vegetable substances, from which the material obtained by the use of solvents was entirely free. The point of capital importance was that all competent persons, whether merchants or manufacturers, who had examined the gutta produced by the new process, had unanimously considered it to be very superior and comparable with the best descriptions which were no longer procurable, much to the regret of the electrical industry. Larger quantities must evidently be made to enable investigations to be made under conditions likely to fix attention on certain details. It was, however, even now possible to assert that solvents would lend themselves if judiciously used, not only to the extraction of gutta-percha but to its commercial treatment and purification.

The author then exhibited a number of samples of gutta-percha obtained by the solvent process.

Contrary to what might have been anticipated from the great oxidability of gutta carbon compounds, the leaves which were sent home much exposed to the action of constantly renewed air yielded a product the quality of which was excellent. It was permissible, therefore, to anticipate an exploitation of the surviving *Isonandra* of Malay, which should be based on the plucking of the leaves and their exportation in a dry state to Europe, where they would be submitted to the solvent process. The very marked characteristics of these leaves would protect manufacturers from fraud, and would give them with some certainty a gutta of excellent quality. Moreover, if it were a question of producing leaves or small branches the immediate return would encourage planters in the extreme East to an outlay the reward for which could not be delayed. Under these circumstances it was permissible to expect more from private enterprise than from the undoubtedly great perseverance and prescience demanded of European States.

Meanwhile it was allowable to anticipate the stoppage, more or less rapid, of the present mode of working. The Malays would sell leaves, which were easy to gather, quite as readily as the gutta itself, which was difficult to extract. Thus, a 30-year old tree, according to M. Sérullas, bore from 25 to 30 kilogrammes of green leaves or about 11 kilogrammes of dry leaves, which would yield by the new process from 1,000 to 1,100 grammes of gutta, while if the tree itself were cut down it would yield at the most 265 grammes. Moreover, according to Malay methods, many times the amount of gutta obtained from the trunk was left in the leaves and small branches. The natives would, doubtless, soon understand that leaf picking carried on during several seasons of the year must bring them in much more money than the laborious work of felling the large trees. Carrying on the same train of thought, a 30-year old tree need only give 7 kilogrammes of fresh leaves, which was but a small yield, to give a continuous return equal to which it would give but once if cut down. Trees of every age and size, at present without immediate use, would, moreover, be available for paying working.

The complete transformation of the present mode of obtaining gutta-percha seemed capable, therefore, of assuring a proper supply of this interesting substance to the European market. It was also to be hoped that private enterprise, by undertaking plantations, to which it seemed possible to promise quick returns, would see to the future.

ELECTRIC RAILWAY MOTOR TESTS.*

BY PROF. GEO. D. SHEPARDSON AND EDWARD P. BURCH.

The experiments here discussed were undertaken for the purpose of obtaining definite information about the performance of electric railway motors under various conditions. There is a diversity of opinion about the relative merits of regulation by rheostat and by commutated fields, the use of one or two motors on a car, value of wetting rails, causes of "bucking," and other points. It is commonly understood that electric roads using rheostat regulation require larger capacity at the generating station than those using the commutated fields. It is also known that one large road has substituted rheostat regulation for commutated fields on all its motors. The tests were conducted for the most part by Mr. Edward P. Burch, a senior in electrical engineering in the University of Minnesota, and by courtesy of the Minneapolis Street Railway Company. Most of the tests were made upon a No. 6 Sprague double reduction motor. Some experiments were also made upon a single reduction motor. Each car axle is replaced by a short shaft carrying a heavy cast-iron wheel with solid web, upon which two oaken blocks are bolted for use as a brake. This was made into a Prony brake. The speed was measured by a common speed indicator with soft rubber tip to prevent slipping. For slow speeds a stop-watch was used, the time for five revolutions of the car wheel being noted. Current and potential were measured by new Weston instruments, about 12ft. distant from the motor.

The Sprague motor armature has 56 sections of eight turns each of No. 12 B. and S. gauge wires. The speed reduction ratio is 11·765. The field coil as used at first was in three sections, coil A 700 turns, coil B of 820 turns, and coil C of 620 turns, all being No. 12 B. and S. gauge wire. By means of the well-known barrel switch these coils are thrown into the following combinations:—

Clip 2, Coils A, B and C in series.
Clip 3, Coils A and B in series.
Clip 4, Coils A and B in parallel, C in series.
Clip 5, Coils A and B in parallel.
Clip 7, Coils A, B and C in parallel.

Several sets of efficiency tests were made with each combination. The three pairs of coils were then replaced by a single pair of coils connected in series, and having several terminals so that the number of turns used might be altered. This was used in connection

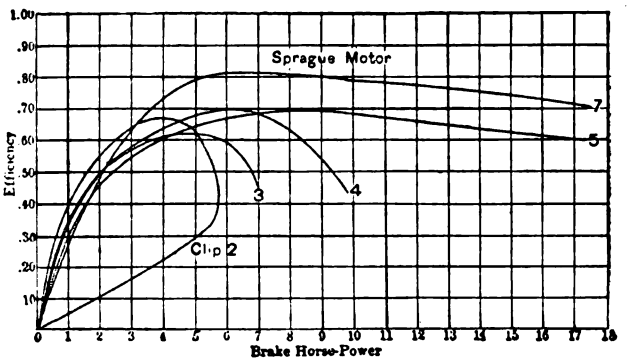

FIG. 1.

with a Thomson-Houston rheostat. In comparing these curves among themselves and with the result of other experiments, it should be noticed that the voltage was considerably below that for which the motors were designed, and that the power delivered was measured at the car axle. The Foucault currents in the cores were probably greater than in the new armatures. With the same armature and fields the efficiency is a few per cent. higher cold than when hot. It has been the aim to run as nearly as possible at the temperature of ordinary running, so that the fields were comfortably warm but not hot. It is confidently believed that the efficiency of these machines would be considerably above 90 per cent. if taken at armature shaft and with full voltage.

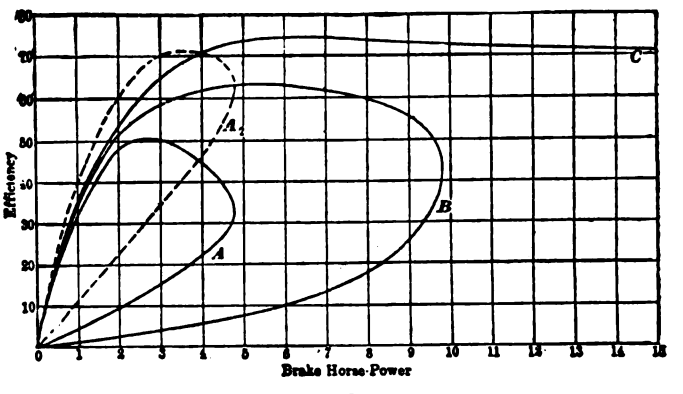

FIG. 2.

Fig. 1 shows efficiency curves for the motor, with different combinations of the field coils.

In Fig. 3, curves A and B show efficiency of the machine with 857 and 611 turns of No. 7 wire in the field coils. It will be noted in Figs. 1 and 3 that the motor has highest efficiency with the larger number of turns on field coils until the iron is saturated, when the better efficiency is given with smaller number of turns and consequent lower resistance in field. This shows the advantage of working on the fifth and seventh clips with barrel regulator, or of cutting out part of the turns on field when the load is heavy. On starting the car the current is very heavy and the field is saturated with a small number of turns; hence the torque with a given current is nearly the same, whatever the windings of the field. The speed and counter E.M.F. are small at starting; hence the potential difference at the armature brushes should be reduced until it passes only enough current to start the car without jerking. The easiest way of reducing the potential difference at the brushes is by interposing

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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resistance; and the heat developed by the C^2R can be cared for more easily and cheaply in an open rheostat than in the field coils. Rheostats of iron and mica are cheaper and more heat-proof than cotton-covered wires. This forces the conclusion that for the heavy load due to accelerating the car at starting, the field should have the smaller number of turns, and as the car reaches normal speed, and the horse-power and current become less, the efficiency of the motor would be raised by increasing the number of turns in the field. This conclusion is exactly the reverse of the common practice of manufacturers who sacrifice some efficiency for speed at small horse-powers. It is also in line with the experience of the road mentioned, that replaced the commutated fields with a single series coil of No. 7 wire, and later with No. 5 wire. This heat loss could be saved and the average efficiency raised by using the two motors in series

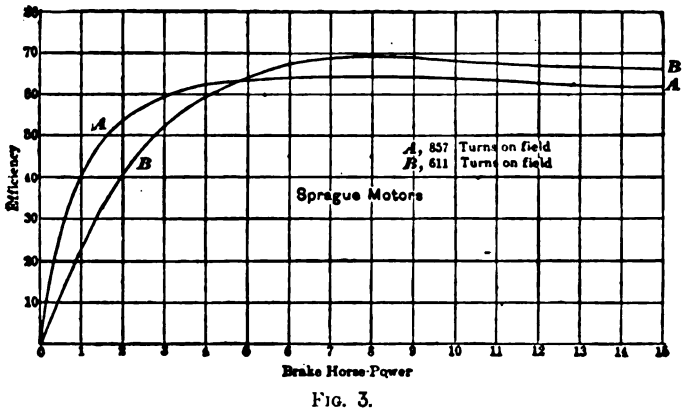

FIG. 3.

at the start, and afterwards cutting out one or putting the two motors in parallel if necessary, as the speed increases and horse-power decreases. An average of 12 tests on the road shows that with two motors on a car it requires 27 per cent. less current if only one is working.

In Fig. 2, curve A shows the efficiency of a Sprague motor with single pair of coils when the whole of a Thomson-Houston rheostat is in circuit. B shows about three-fifths of the rheostat in use; and in C it is all out. The dotted line A_2 gives the efficiency as calculated from the difference of potential about the motor alone. Curve A_2 is not strictly comparable with the others on account of the necessary variations in the voltage at the motor; but it does show the increased efficiency to be obtained by utilising the superfluous voltage in a second motor in series. In this connection it is interesting to note that the resistance of rheostat, as calculated

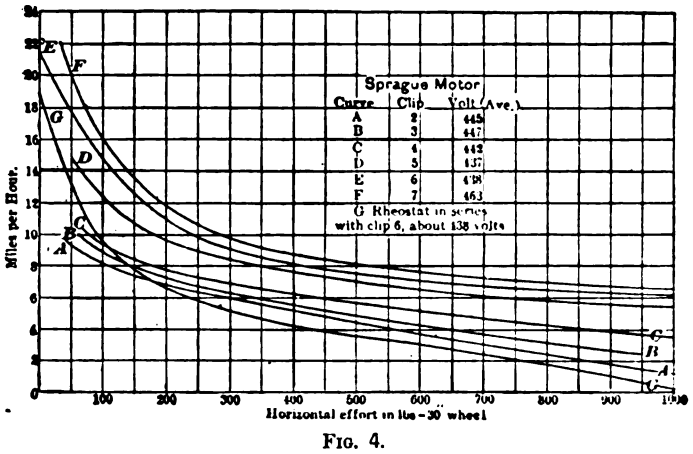
Miles per Hour.
Horizontal effort in lbs.-30" wheel
Sprague Motor
Curve | Clip | Volt (Ave.)
A 2 445
B 3 447
C 4 442
D 5 437
E 6 438
F 7 463
G Rheostat in series with clip 6, about 438 volts

FIG. 4.

from current and potential difference, decreases with increase of current. This is as expected, since the larger part of the resistance is due to surface contact between the plates of iron in the rheostat, these being pressed together more closely as the iron heats. A similar effect, but much more marked, has been noticed in earlier experiments by one of us with alternate plates of carbon and iron.

Figs. 4 and 5 show curves of torque, speed and horse-power referring to the No. 6 Sprague motor. In Fig. 5 A shows horse-power and horizontal effort on a 30in. wheel; B, C, D, E, and F clips 2, 3, 4, 5, and 7 respectively. Fig. 6 gives curves of current, torque, speed, and efficiency from a 15 H.P. Thomson-Houston single reduction motor. The reduction ratio is 4·78.

A number of load diagrams are given in the Paper. One of these, relating to the Minneapolis Street Railway Company, Station 1, shows a current varying from 1,300 to 2,700 amperes.

The "bucking" of street car motors is a subject of considerable interest to street railroad men, although it seems never to have been discussed in public. It sometimes happens that an electric car suddenly stops, as if by collision. In some cases the car refuses to go further, but usually it goes ahead immediately, as if nothing had happened. This is known among railroad men as "bucking." To explain the action, it is noted that in common practice the motor fields are connected between the armature and trolley, the armature being grounded at the negative brush. If a second ground occurs on any part of the machine except between

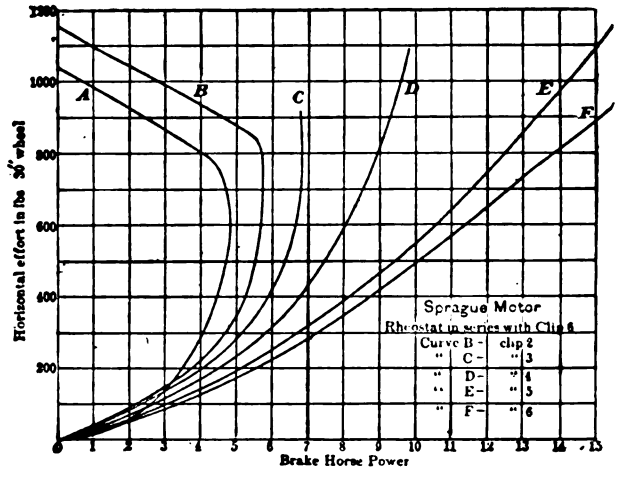

FIG. 5.

the fields and trolley, a heavy current passes to ground, giving an intensely strong field, while the armature is short-circuited by reason of the two ground connections. It therefore acts as a dynamo short-circuit, and becomes a powerful electric brake, that stops the car very suddenly.

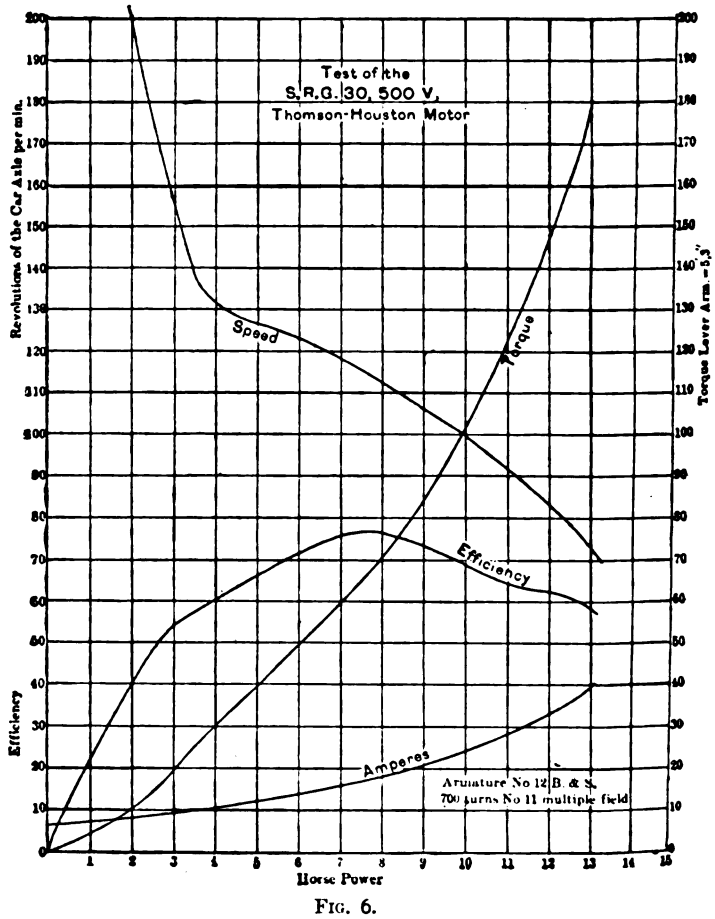

FIG. 6.

Sometimes a car will buck at regular intervals. Examination of the motor shows a small bright spot on one brush, which rolls to and fro at the contact between brush and commutator. This is intensely bright, like a ball of melted metal, and grows larger until nearly three-fourths of an inch in diameter, when it suddenly

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explodes with considerable noise and a blinding flash, and at the same instant the motor bucks. The car goes on again at once, and the cycle is repeated again in the time required to run from one-half to four city blocks at ordinary speed. In such a case the bucking is stopped by shifting the brushes. The carbons are sometimes placed carelessly, so that the presser-foot rests partly on the carbon and partly on the holder. This presses the carbons against the commutator so as to give good contact until the carbon wears off a little, when the presser-foot no longer feeds in it. Vigorous flashing occurs, culminating in a buck, the shock of which may jar the presser-foot into its proper position, when the motor runs on as if nothing had happened, leaving behind no trace to indicate the cause of trouble.

The motors with Gramme ring armatures are known to buck more frequently than those with drum armatures. These buck worse when run on the "loop," *i.e.*, with part of the field coils cut out, some of them bucking regularly every time the loop is cut out This is one reason why the use of the loop has been abandoned on this road except in a few cases. In searching for a reasonable explanation for all these cases in which no second ground connection existed, it was noticed in each case that bucking was more liable to occur when the field was comparatively weak; also where the armature reaction was greater. In each case the neutral line is shifted, and the coils under the brushes are in an active field. The large current in short-circuited coils further distorts the field, and the sparking at the brush becomes excessive, causing a vigorous flashing. As soon as the counter E.M.F. in the sections leaving the brushes rises above 20 volts, the arc is carried around from one brush to the other, thus grounding the positive brush and short-circuiting the armature, which then acts as a dynamo and causes the motor to buck. Such bucking is usually less vigorous than when caused by a dead ground, on account of the resistance of the arc. This explanation covers all the cases noted.

Such being the causes of bucking the remedies are plain. Armature reaction must be reduced. An obvious remedy for bucking caused by direct grounding would be to connect the fields between armature and ground instead of between armature and trolley. With such an arrangement, a ground on the fields would simply cut out a part of the coils, and cause that machine to work harder. A ground at brush between armature and field would cause a sudden forward impulse on account of the field requiring some time to lose its magnetism, and would blow the fuse. A ground on armature would likewise cause a sudden forward impulse and blow the fuse. With such an arrangement there would be no true bucking except in case of the flashing as noted. An incidental advantage of this arrangement is that the difference of potential between the field and the frame of the machine is reduced to a few volts caused by the drop through the field; hence there is less danger of grounding the field. The increased difference of potential between armature and core is only a few volts, and would not affect the insulation very much.

VOLTAIC CELLS WITH FUSED ELECTROLYTES.*

BY J. BROWN.

In comparisons of the observed electromotive forces of voltaic combinations with their theoretical values, as given by Thomson's law, the discrepancies frequently observed are probably to a large extent caused by the action of the solvent—usually, of course, water—especially in the cases of easily oxidizable metals, such as magnesium and aluminium. The solvent may possibly act as an electrolyte, or it may act indirectly by the formation of insoluble protective films on the metals. There is also some uncertainty as to how far the heats of solution of the products formed in the cells are adjuvant. These difficulties led to the consideration of a simpler form of cell, in which the solvent is abolished and the liquidity of the electrolyte is produced by fusion.

I.—*Cells containing Single Chlorides.*

Certain chlorides were chosen for the electrolytes as being fusible and otherwise suitable. The cells were of the two-fluid type, Zinc | $ZnCl_2$ | $MgCl_2$ | Magnesium.

Although the action of atmospheric oxygen cannot be said to be excluded, and there was probably some action between the two chlorides themselves, the results correspond much better with theory than those obtained with the aqueous form of cell. In the actual experiments one of the chlorides was fused in a V tube, into one limb of which a short straight tube, plugged below with asbestos and containing the other chloride, was then inserted. Precautions were taken to mitigate any effects of the mixture of the two electrolytes and keep the temperature uniform in the cell. The appropriate metals were placed in their chlorides in the tubes, and the electromotive force of the cell so formed was carefully measured on a Thomson electrometer, and compared with that of a Daniell cell, whose force was estimated at 1·13 volts.

A set of experiments was made on all possible combinations of the metals silver, copper, tin, lead, cadmium, and zinc in their chlorides. The theoretical electromotive force was assumed to be proportional to the difference of the combining heats for chlorine of the two metals in any given cell. This difference divided by 50,130, the heat-equivalent of the Daniell, gives the theoretical force of the cell in terms of the Daniell; or the heat-equivalent of each metal was first divided by 50,130, and the difference of any two quotients so obtained taken as the theoretical electromotive force for the cell containing the corresponding metals. On comparing the values so found with the observed electromotive forces there was fairly good agreement in cells containing any combination of zinc, lead, and tin, but not so good where silver, copper, or cadmium was concerned. It was found, however, that the application of certain corrections to the quotients for each metal as described above gave theoretical values in much better agreement with the experimental results, so much so that out of the fifteen observed cases only two differ as much as 0·03 from theory. The results are given in two tables, one containing the uncorrected and the other the corrected results.

The physical cause underlying these constants is believed to be connected with the higher temperature of the experiments as compared with that at which Thomson's heats of combination (the data employed in the theoretical calculation) were obtained. This view was confirmed by experiments on cells consisting of a single chloride only fused in a V tube with a piece of the metal contained in it inserted in each limb and connected with a galvanometer.

On heating one limb more than the other a current was produced in all cases except that of cadmium, the hotter metal being the positive pole. Metal was transferred from the hotter to the cooler pole, showing the electrolytic nature of the phenomenon, and suggesting, in the light of Thomson's law, an increase with temperature of the combining heats of the metals with chlorine, conjoined with a possible Peltier effect.

The reversibility of some of the cells was tested by passing currents through them in opposite directions and noting the electromotive force after each current had passed for some minutes. In the combinations, zinc-copper and zinc-lead there was no evidence of polarisation; with zinc-tin a minute effect, and only in the case of zinc-silver was there distinct polarisation amounting to about 2·4 per cent. of the whole force of the cell.

II.—*Cells containing Double Chlorides.*

As stated above, it was desirable to test cells in which the easy oxidisable metals such as magnesium and aluminium took part. The difficulties of working with the chlorides of these metals in the fuse state were got over by employing their compounds with alkaline chlorides, and the same method was adopted with the infusible ferrous chloride. Although the alkaline chloride may here be said to become the solvent of the metallic chloride combined with it, it is assumed that owing to the high combining heat of the alkaline chloride, and the fact that its anion is the same as that of the chloride combined with it (or dissolved in it) no serious complication is introduced by its direct action on the metals, as in the case of water when used as a solvent. The heat of solution of the one chloride in the other must, however, be considered, and in order to avoid, as far as possible, complications from this source, it was found best that in any given cell the two chlorides employed should be either both double or both single. Experiments were made on cells containing all possible combinations of the metals, silver, copper, tin, lead, iron, cadmium, zinc, aluminium and magnesium, in their double alkaline chlorides. The experiments were carried out in the same way as that described for single chlorides, with the result that in the cases of aluminium and magnesium the difference between experiment and theory does not exceed 0·2, while in aqueous cells it is found to be from four to five times as great.

The use of a correction for each metal in the way described above produces a still better agreement. After the application of the nine corrections required, the difference in no case, out of the thirty-six pairs examined, exceeded 0·07, which may be considered satisfactory taking into account the complication introduced by the alkaline chloride. The results for this set are also given in tables.

Since writing the above Paper my attention has been called to a Paper by L. Poincaré (*Comptes Rendus*, Chap. X., page 339), in which there are described some experiments on the thermo-electromotive forces of zinc and tin in their chlorides at unequal temperatures. The force of a zinc | $ZnCl_2$ | $SnCl_2$ | tin cell is also measured, and gives a result very near nine. M. Poincaré considers that in calculating the theoretical values for such cells the heat of fusion of the salts should be considered. It would seem that there may be on theoretical grounds some doubt on this point. Data for deciding it experimentally are not available.

* Abstract of a Paper read before the Royal Society, June 16, 1892.

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MOTORS AND THEIR MODIFICATIONS.

The recognition of one's environment and the adaptation thereto are among the first essentials of happiness. When the square man finds himself in a round hole, one or the other—he or his environment—must give way if existence is to be endurable. And as with men so with machines, progress consists in development rather than in creation, and by far the largest proportion of mechanical inventions are adaptations and not new species. Sometimes the evolution is so gradual that the history is hard to trace. No one can point to the first steam engine or to the first dynamo, but no sooner had these machines become practicable than they began to be adapted to one special use or another. A new need has generally called forth a new modification; but while electrical energy is so readily applicable to widely different purposes dynamos and motors have appeared in less numerous forms than steam engines. The factory engine, the marine engine, and the locomotive differ more, both in outward appearance, in the nature of their work, and in the details of their design, than any classes of dynamos. We have alternate-current and continuous-current machines, it is true, and the latter exhibit important differences between constant-pressure and constant-current machines; so different, in fact, that the one would be useless if put to do the work of the other. But great as these differences may be, no one but an expert could possibly distinguish one from the other; and if the jury of an Electrical Exhibition were confronted with a new dynamo they would find considerable difficulty in guessing its output, and for what purpose it was best suited. It has been

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shrewdly observed that in Germany, dynamos have been built to suit the steam-engines, and in England steam-engines have been designed to fit the dynamos. So far, the dynamo will lend itself to moderate adaptation; but setting aside the difference between bi-polar or multi-polar machines, as depending largely on mere size; and speed and output, as mere details of winding, the dynamo does not allow of any such varieties for special purposes as we find in the steam-engine. The cylindrical armatures of CROMPTON and SIEMENS differ in appearance from the disc armatures of SCHUCKERT and GÜLCHER; but no one claims that any particular shape presents peculiar advantages for a given piece of work.

Closely allied to dynamos we find that motors are to some extent at a disadvantage compared with steam-engines in adaptability. It may be said that a motor consists only of an armature and a set of magnets, and that many changes cannot be rung on these. If we take one class of work for which steam-engines are often used, that of pumping water, we find the beam engine in use for the heaviest work, reciprocating engines specially designed without cranks for direct horizontal pumps, and high-speed engines differing altogether from the others for driving centrifugal pumps. But when we turn to electric motors for the same work we find no sign of adaptability. Each maker has three or four sizes of motor of the ordinary stock pattern, and he gears it to a three-throw or other pump with gear wheels or belt. This seems to be essentially un-English; and as we are conscious of the fact that the motor is not easily altered, the pump ought to give way. Seeing that the efficiency of a motor is intimately connected with its speed, the first idea, obviously, is to run the pumps faster and make them proportionately smaller. But hydro-dynamical difficulties of eddies and friction forbid this. Reciprocating motors are at present out of the question, seeing that they are urgently wanted for rock-drills, and have not responded to the call. The centrifugal pump, again, is not always applicable, as it needs charging, and a foot valve is often a nuisance. Hundreds of rotary pumps—most of them would-be rotary engines—have been invented; and some of these, especially those of the Root type, might be driven direct from fast-running motors. It is possible that alternate current motors will be more accommodating; and now that electrical engineers are something more than electricians, they may perhaps find that these motors can be more readily altered to suit the machinery than *vice versa*.

COMMUTATORS.—II.

BY F. M. WEYMOUTH.

(*Continued from page 246.*)

Now, though the difference of potential between adjacent segments may be slight, yet this varies from a minimum at the plane of commutation to a maximum at the sides of the commutator, in a plane at right angles to the plane of commutation. For assuming the plane of commutation to be vertical, and so the brushes at top and bottom, and the segments approximately in the same plane with the coils with which they connected, those segments at the sides connected to coils lying horizontal are collecting potential at a maximum rate; while the vertical segments at the top and bottom are connected to coils which are generating practically no potential. As regards drum-winding, this point was made clear in the article already alluded to, which appeared in *The Electrician* for July 19, 1889. The reasoning would be very similar in reference to Gramme-winding. But in consequence, the insulation between the segments must be sufficient to withstand this maximum difference of potential that occurs at the sides half way between the brushes. On the question of insulation, however, that between the bars and the substructure requires special attention; for there is the difference between the whole potential of the machine and the zero potential in the substructure to deal with. Here the insulation may be an eighth of an inch or more in thickness, and may consist of vulcanised fibre, mica, asbestos, or other material. Between the segments, it may be mentioned, mica is specially suitable owing to its natural cleavage, which allows of its easily being split into the very thin sheets required. Moreover, it is hard and well adapted to resist the compressive strain brought upon it, and so, with the segments, help them to form a solid mass compact together.

Now, while on this subject of insulation, and inasmuch as the substance commonly known as "fibre" is so largely in use for this purpose, it may be of interest perhaps to add some remarks concerning it, for which we are indebted to a somewhat complete *résumé* on the subject by manufacturers of this material. Vulcanised fibre is produced by chemically treating specially prepared vegetable fibre, whereby the exterior portion of each separate filament becomes glutinous. While in this condition, the whole mass is consolidated under heavy pressure, and rendered practically homogeneous. The chemicals are then extracted, and the mass is manipulated, rolled, pressed, and cured by various methods. These operations being of an extremely delicate nature, liable to vary with different conditions of atmospheric moisture and temperature, it requires great skill, care, and experience, as in many other manufactures, to produce uniformly good results. Besides possessing its well-known qualities of strength, elasticity, and durability, this material has the further qualities of not being soluble in any ordinary solvent, and is not injured by contact with petroleum or any of the animal, vegetable, or mineral oils. It does, however, which it is important to note, *absorb water*, either hot or cold; though it is not injured thereby, merely swelling when wet, and resuming its original size when dry again. Such absorption taking place would, of course, be fatal to its quality as an insulator. The vulcanised fibre is made in two qualities, "hard" and "flexible;" though for purposes of insulation the hard quality alone is applicable. A peculiarity is that this substance is produced only in sheet or tube forms. It will not mould; hence all objects to be made from it require to be cut out of either of these two forms, whichever may be the most suitable. The sheets, in size about 40in. by 60in., vary from $\frac{1}{50}$in. to $1\frac{1}{4}$in. thick, and are supplied in three colours, red, grey, and black; while the tubes, produced in lengths approaching two feet, have a thickness of shell not exceeding half an inch. It appears that these latter cannot be manufactured of less than $\frac{5}{16}$in. inside diameter, and the thickness, moreover, is proportioned somewhat to the diameter in the small sizes. Being rolled perfectly true and straight, with a good finish, they may be cut off into washers, or be used in lengths for enclosing and insulating bolts, and so forth. Having no grain, this material may be worked into all manner of shapes. Its specific gravity is about 1·3, and a cubic inch weighs about four-fifths of an ounce.

Vulcanised fibre, originally imported from America, has been put on the market in England and the Continent as an insulator, and having some insulating qualities, and being easily worked, has been very generally adopted. In this connection, however, we may give a table of specific resistances, compiled from measurements taken by Profs. Ayrton and Perry, and which we quote from *Uppenborn's Electrical Calendar*.

Vulcanised fibre	$1{\cdot}2 \times 10^6$	megohms	(B.A.)	at	20°C.
Mica	84·0	„	„	„	20°C.
Gutta-percha	450·0	„	„	„	24°C.
Shellac	9000·0	„	„	„	28°C.
Hooper's vulcanised India-rubber	15000·0	„	„	„	24°C.
Ebonite	28000·0	„	„	„	46°C.
Paraffin	34000·0	„	„	„	46°C.
Glass	Still greater.				

From the above it will thus be noted that fibre ranks last as an insulator. Now, with the *India-Rubber and Gutta-Percha, &c., Trades Journal* (May 9, 1892) as our authority, we there find an account of some experiments made as to the specific resistance of vulcanised fibre by Mr. Eugen Müller, of Berne, the original of which appeared in the *Elektrotechnische*

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Zeitschrift (February 5, 1891).* The liability of fibre to absorb moisture has already been intimated. To how great a degree this liability extends, however, will be made clear from the following tabulated results of these experiments. It is to be observed that these were made under three different conditions. Firstly, the fibre was previously thoroughly dried by being enclosed in an exsiccator for several weeks; secondly, experiments were made after its exposure for 24 hours only to the by no means damp atmosphere of the laboratory; and, thirdly, after exposure for several months. Results with walnut wood are also included. (Ω L = Legal megohms.)

Specific Resistance (at 15°C.) per Cubic Centimetre.

—	Dry.	Exposed 24 hours.	Exposed several months.
	A.	B.	C.
1. White vulcanised fibre	$2,500 \times 10^6$ Ω L.	200×10^6 Ω L.	14×10^6 Ω L.
2. Different kind ,,	3,300 ,,	1,080 ,,	22 ,,
3. Light brown ,,	7,400 ,,	580 ,,	18 ,,
4. ,, ,,	12,400 ,,	1,002 ,,	54 ,,
5. Red ,,	16,500 ,,	245 ,,	10 ,,
6. Black ,,	20,500 ,,	2,000 ,,	68 ,,
7. Red ,,	35,400 ,,	3,250 ,,	54 ,,
8. Brown ,,	48,500 ,,	3,800 ,,	26·3 ,,
9. Ordinary walnut wood	99,000 ,,	2,870 ,,	53 ,,
10. ,, ,,	49,500 ,,	21,000 ,,	572 ,,
11. Paraffined ,,	∞	$620,000 \times 10^6$,,	3,690 ,,
12. ,, ,,	∞	$185,000 \times 10^6$,,	11,080 ,,
13. ,, ,,	∞	11,700 ,,	1,380 ,,
14. ,, ,,	∞	∞	830 ,,

It will thus be seen that though fibre, when perfectly and absolutely dry, has decided insulating qualities, it rapidly deteriorates in this respect with exposure. The loss, in fact, is tremendous, even in the first 24 hours. But in the humid climate of England, wherewith by far the greater part of the year the atmosphere is damp, the first two columns in the table would with the better reason be considered as appertaining to a condition of things contrary to general experience. For safety, the last column (C) is the one on which calculations should be based. We here find the specific resistance ranging from 10×10^1 megohms (L) for one specimen of red fibre, to 68×10^6 megohms for a black specimen.

The means of the results, however, are given as follows:—

White vulcanised fibre	about	18×10^6 Ω L
Brown ,, ,,	,,	26×10^6 ,,
Red ,, ,,	,,	32×10^6 ,,
Light brown ,,	,,	36×10^6 ,,
Ordinary dry walnut wood	53 to	572×10^1 ,,
Paraffined ,, ,,	530 to	$11,000 \times 10^6$,,

* Referring to this article Mr. W. Courtenay, President of the Vulcanised Fibre Company, writes to point out the rapidity with which ebonite or vulcanite (even when it is of the best quality, which is seldom the case) deteriorates with age, whilst vulcanised fibre actually improves, and after eight or ten years has been found in a better state than when first put in. Moreover, ebonite or vulcanite is almost always adulterated, and in time becomes perfectly perished, and its only claim to being considered an insulator lies in the fact that it is waterproof. Mr. Courtenay entirely denies that vulcanised fibre contains either jute or oxide of iron, as asserted by Herr Müller. All Herr Müller's figures giving comparisons with paraffined wood are, says Mr. Courtenay, quite irrelevant. As everyone knows, paraffin is one of the best non-conductors, and wood being exceedingly porous, the tests given refer in reality to the paraffin, and not to the wood. It is not to be denied that ebonite and vulcanite when pure (which they seldom are) have a higher resistance against high potentials than fibre. Against this must be balanced the mechanical weakness to which they are liable. Herr Müller is aware that the hygroscopic properties can be entirely done away with by giving it a coating of shellac or other watertight varnish, whenever circumstances would otherwise allow it to absorb moisture. Mr. Courtenay states that it is by no means certain that Herr Müller had got hold of genuine specimens of fibre, as many imitations of the genuine article had been produced. In answer to this Herr Müller, in a later issue of the *Elektrotechnische Zeitschrift*, states that the specimens of fibre tested were obtained from the sole agent of the Patent Vulcanised Fibre Company, Herr Wilfert, of Cologne. To this the latter replies that he has only supplied Herr Müller with a small sample of fibre, and that nearly two years ago. He also says that since the Vulcanised Fibre Company supply only one sort of fibre, whilst Herr Müller gives the results of tests on eight different varieties, there must be an error in supposing that the material experimented on was prepared by the Vulcanised Fibre Company.—[ED. *E.*]

In the first table we quoted it will have been noticed that the specific resistance of mica was given as 84×10^6 megohms (B.A.), at 20°C. This is considerably better than any results with exposed fibre, though by no means high as compared with the other insulating substances that follow it in the table.

It is obvious, however, that the whole question of insulation is bound up with the consideration of what is practicable and practical under any given conditions. Thus, in the case of commutators, with which we are more immediately concerned, mica, from its natural cleavage and hardness, is eminently suited for putting between the flat sides of the segments. For this purpose, therefore, it has been largely adopted. If we consider the various substances that are used generally for insulation, such as glass, porcelain, paraffin, ebonite, vulcanite, India-rubber, gutta-percha, besides mica, fibre, and so forth, we find none of the first named are applicable for use in commutators—or, at least, are not used to our knowledge. India-rubber and gutta-percha are too soft; ebonite and vulcanite are too friable, and wanting in strength; glass and porcelain have a certain strength; and though one may be tempted to look at these, the practical difficulties of adapting them to a fit would be great, besides the question of their extreme brittleness, and liability to chip, crack, and break. In a commutator, the insulation has to form part of the general structure, and has to take strain in common with other material used. This at once limits the substances that are applicable. For the necessary strength, therefore, together with practicability of working and other qualifications, we find ourselves more or less confined to vulcanised fibre and mica, though asbestos and other materials have been adopted.

Now, the excessive hygroscopic properties of fibre, to which we have been drawing attention, and which interfere so largely with its quality as an insulator, cannot unfortunately with any success be diminished by paraffining. For on account of its very inferior porosity, the temperature of the paraffin has to be raised very high (about 180°C.) to make it penetrate; and at this heat the fibre decomposes with effervescence, becomes brittle, and is rendered perfectly useless. Other drawbacks to fibre, however, are that it swells with absorbed moisture, and warps with heat; and commutators are liable to get warm. It is thus for these various reasons that some firms now are abolishing vulcanised fibre altogether from their commutators, and are using mica throughout. We hence propose now to give our attention more particularly to this material, and its adaptability for use in commutators—for the cones especially.

Touching briefly on the sources whence mica comes, it may be stated that it is found and mined, among other places, in New Zealand, Australia, Canada, Bengal, Madras, and Ceylon. There are various kinds of mica, and the term is applied to a group of crystalline rocks having the peculiar laminated structure well known. While a small specimen may easily be sliced thin through the cleavage with a pocket knife, on the edge it is about as hard as slate. Though it is found in slabs sometimes two or three inches in thickness, it cannot be worked like slate, nor even as though it were hard wood or soft metal. When required of any particular shape, size, and thickness it is necessary to build it up to the approximate dimensions of thin slices, separately worked, and all cemented together. The mass thus built may then be finished off by subsequent tooling. At the recent Electrical Exhibition at the Crystal Palace there were two exhibits of this substance, in the gallery, by Messrs. F. Wiggins and Sons, and Messrs. Wake and Sanders. In both of these there was a plentiful display of mica strips cut for use between the segments of a commutator. The former exhibitors, however, added two mica rings built up in the manner described, which were ready prepared for turning down into cones for commutators. These were to be observed in a case containing various very fine specimens of machined work, placed round the foot of a column of turned mica, which latter was doubtlessly unique in the Exhibition, as showing what can be produced with this material with proper knowledge and skill in its manipulation. Reverting to the rings, however, these are by no means wanting in strength. For, besides being hard on the edge, mica is also tough. A thin sheet will bend considerably before breaking. But

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unless built up in the manner described, it has no great strength to resist parting in the cleavage. Some firms build up their own rings, though, as intimated, they may also be had from the makers, leaving only the turning to accomplish. From a practical point of view indeed, this latter course would probably be generally necessary, inasmuch as very heavy pressure is required for making the rings; those at the Exhibition for instance, though only about 8in. in diameter and $\frac{3}{4} \times \frac{3}{4}$in. in section, requiring no less a pressure than 175 tons. But in this manner cones may be obtained of sufficient strength, and as regards insulation and other qualities, considerably superior to vulcanised fibre.

Having now thus reviewed some of the different points that occur in connection with the design and construction of commutators generally, we may proceed perhaps with advantage to the consideration of definite examples. In so doing, it may be helpful to adopt some kind of classification. Thus a general division may be drawn between those designed to give the greatest depth of wear for the brushes, and those in which shortness of length has been made a special object. Figs. 3 to 6 herewith illustrate designs of the first-class, each showing

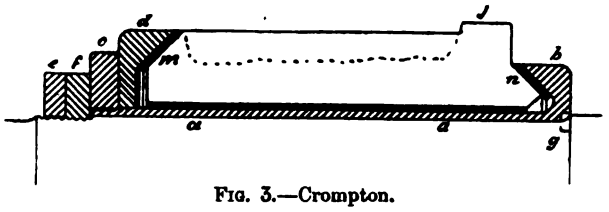


Fig. 3.—Crompton.

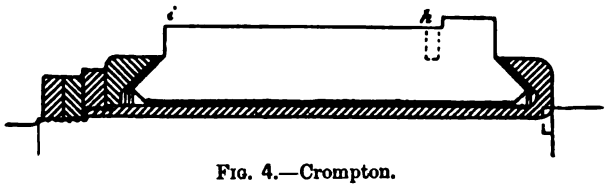


Fig. 4.—Crompton.

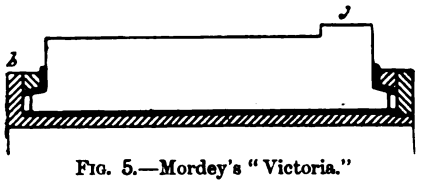


Fig. 5.—Mordey's "Victoria."

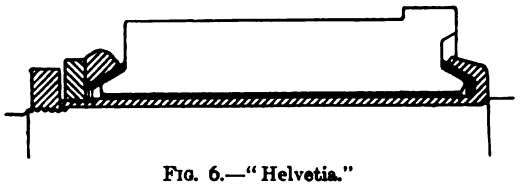


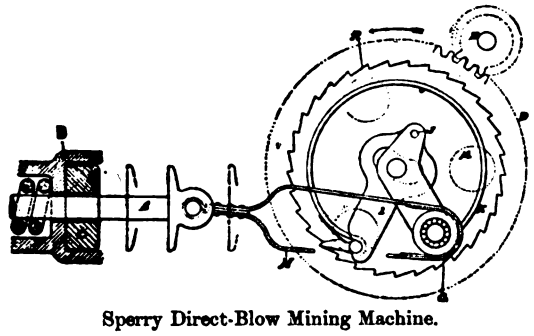
Fig. 6.—"Helvetia."

a longitudinal section through the upper half of a commutator only, similar to the upper half of Fig. 2, as with other figures that follow. Figs. 3 and 4 show two forms of commutator as made by Messrs. Crompton and Co., Limited. Fig. 5 is that of Mordey's "Victoria" dynamo; and Fig. 6 shows the commutator of the "Helvetia" dynamo constructed by Messrs. Alioth and Co., of Basle. It should be mentioned, however, in reference to these and succeeding figures that they are not scale drawings from specific examples; and though suited for the purpose of this article, no guarantee is intended that they all illustrate present day practice. Few parts of a dynamo probably are more affected by change than the commutator; and it is our purpose to discuss the reasons that lead to such changes, rather than merely to illustrate ultimate results. Now, the leading principle of all these, it is to be observed, is that of endurance. For there is no limit to the depth to which the bars may be worn down. They may in fact be worn right through—an occurrence which is not unknown; though allowing a commutator to run so long instead of renewing at an earlier period is perhaps scarcely commendable. This is, however, a leading point in these designs. Regarding them more closely, we note that they are all mounted on a sleeve or bush *a a*, which in Figs. 3, 4 and 6 has a mushroom head, *b*. In Fig. 5 the head is flat, and is placed at the contrary end to that where the shoulder *j* for the lugs occurs, as compared with the other figures. The segments are held on by a nut and washer *c d*: and in Figs. 3 and 4, the whole commutator is held on the shaft by a nut and lock-nut *f e*. In Fig. 6 only one nut is used for this latter purpose. The solid black represents insulation. Now with regard to Fig. 3, it will be noted that the washer *d* is of the same diameter as that of the combined segments. Thus it differs from the other designs in that these latter have a clear shoulder at the left end, as shown lettered *i* in Fig. 4. It may perhaps be said, without its being stated as a set rule, that Fig. 3 is more especially suited for small sizes. For this, referring to the nuts and washers, would be on the general principle that parts should never be too small absolutely. On a large scale certain parts might be minute in proportion to the whole, but not so absolutely—or in other words—to the size of a man. The same parts on a smaller scale would need to be of increased size in proportion to the whole, to avoid being too small absolutely. Beyond this consideration, however, a clear shoulder as at *i* allows of an unhampered peripheral surface for wearing down. A groove turned at the other end as shown dotted at *h*, Fig. 4, leaves a surface clear at both ends. In Fig. 3 the dotted line shows how the wear is confined and hampered at both ends, and illustrates the difficulty, if not impossibility, of keeping the wear even all along, so as to avoid sparking. The surface *i h* in Fig. 4 has not these difficulties. In a patent for this groove *h* taken out by Mr. J. W. Easton, of New York, it is recommended that it should be kept filled with some easily removed insulating material, to prevent its filling with metal dust from the wear of segments and brushes, which might otherwise cause short circuits between the bars. Though familiar with the idea of the annular slot some time before the date of this patent, we are not aware to what extent, and with what success, this method has been adopted in practice.

(To be continued.)

THE SPERRY DIRECT BLOW MINING MACHINE.

In a Paper on Electricity in Bituminous Mining read before the American Institute of Electrical Engineers, by Mr. E. A. Sperry, a reciprocating mining machine is described. Mr. Sperry



Sperry Direct-Blow Mining Machine.

has gone back to an ordinary high-speed motor, and obtains a reciprocating motion by an ingenious mechanism. This is described in his Paper in the strange dialect of the American language which is adopted by patent agents in the United States. We reproduce the diagrammatic illustration, but have translated the description. The reciprocating shaft A carries the mining tool at one end, not shown in the illustration. A strong spiral spring B drives the shaft forwards, and the electric motor draws it back. A buffer or cushion C is provided to take the shock when the tool is not brought up to the work. The spring gives an initial pressure of 500lb. A link or slotted connecting rod H is pinned to the end of the shaft A, and is retracted against the pressure of the spring by the crank pin G. This crank is mounted loose on the shaft. An arm I is pivoted at *s* to a lug on this loose crank, and carries a pawl which engages in the internal ratchet teeth of the wheel D. This arm is connected to the crank by a long hoop-shaped spring K. When in the

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position shown in the illustration, the motor, which is kept continually running, drives the wheel D in the direction shown by the arrow, and its motion is transmitted by the ratchet tooth, pawl, arm I, to the crank G. Thus the shaft A is drawn back by the link H until the crank arrives at the dead centre M. As soon as this is passed, the powerfully-compressed spring B drives the shaft and tool forward, giving the working blow, and drawing the crank round much faster than the ratchet wheel. The tool when at work does not, of course, make the full outward stroke, but is brought up at some such position as A. The crank is at that moment at the position shown by the dotted circle *n*. The link H being slotted, there is nothing to stop the crank, and it is carried forward by its momentum to a corresponding position on the other side of the centre, where it is stopped by the link. The ratchet wheel being in continual motion, the pawl engages, and winding-up is recommenced at once. From 160 to 225 strokes are made in a minute. It is stated that "the mean effect of this type of machine is 935lb. when allowed to strike the cushion," and when striking the work at a distance of one inch from the cushion gives "1,000lb. mean effect." The mean effect in air machinery employed for the same purpose is between 400 and 450lb., a 3¾-in. cylinder being the largest employed. The current is 10 amperes at 220 volts; the shaft and tool weighs from 100lb. to 150lb. It is found that the whole machine must be fairly heavy to take the recoil. We have recorded numerous attempts to construct direct acting solenoid machines for producing a reciprocating motion, but no really successful one has yet appeared. Much current is generally wasted in starting the armature at each end of the stroke. In a steam cylinder nothing is wasted in imparting a high initial pressure during the period at which the piston is at rest or is just beginning to move, for no steam is expended. But in a magnetic reciprocating machine, a steady flow of current must take place during this period, and the current will probably be greater than at other periods because the armature is more or less stationary.

TELEPHONIC AND CONTINUOUS-CURRENT CIRCUITS.*

BY A. PALAZ.

At the beginning of the telephonic industry, when telephone exchanges were being inaugurated, the exquisite sensitiveness of the microphone and telephone called forth every one's admiration. If this feeling has not diminished with the *sarant* it has certainly completely disappeared so far as the practical man is concerned; he would vastly prefer more powerful microphones and less sensitive telephones. Indeed, we must attribute the fact that long telephone lines are never completely silent to the great sensitiveness of that instrument. Such lines are always the seat of excessively weak variable currents, which make themselves felt in the telephone in the shape of various noises more or less intense, but which it would be otherwise difficult to detect even with the most sensitive measuring instruments. These parasitic currents are due to a variety of causes; and it is no easy matter in any given case to assign each its proper relative value, a fact which greatly complicates the investigation of the methods to be adopted in order to completely suppress the disturbances on telephone lines. On lines which complete the circuit through earth the influence of terrestrial electrical phenomena is especially noticeable. Any telephonic wire which goes to earth at either end is subjected to all the variations of the earth's potential, produced either by meteorological or electro-industrial causes. It is, therefore, difficult to find on a single-wire urban system a line on which one cannot hear the telegraphic signals passing along the wires which terminate at the town telegraph office. The successive emissions of current give rise to undulatory variations of the earth's potential, and these variations reach the telephone line by the earth plates, and the latter becoming polarised give rise in their turn to variable currents resulting in parasitic noises. Atmospheric influences are also of great importance; the variations in the electrical condition of the air are reproduced on the telephone line in the shape of variable currents (earth currents). In times of storms, for instance, when the atmospheric electrical discharges suddenly upset the atmospheric electric equilibrium, telephone lines are the seat of powerful parasitic currents, which materially greatly augment the disturbing noises which are then particularly irregular. Lastly, we ought to mention the currents induced by the swaying to and fro of the wires in the magnetic field of the earth under the action of the wind. These last telephonic disturbances are of meteorological origin and impossible to completely avoid. But the same cannot be said for the parasitic noises due to the neighbouring wires traversed by variable currents, telegraphic or industrial; this action may either be due to induction or to stray currents from the other lines arising from bad insulation. This is the explanation usually given of the disturbances produced by industrial currents in telephone lines.

Owing to the great development of industrial electricity the stray currents from industrial circuits have become more and more the principal disturbing element of telephonic traffic. Lighting and telephone circuits are being developed together, and they are mixed up with one another. Telephone lines and their earth plates are in the immediate vicinity of wires connected to electric lighting apparatus, so that the slightest leakage to earth from an industrial circuit finds an easy path into the telephone lines. All the variations of consumption on the industrial circuit are, therefore, felt on the telephone circuit, in which we may note the variations in the output of the machines by the variations in the parasitic disturbances.

In the case of continuous-current industrial currents, and in this article I shall only consider such, we may assume as a fact demonstrated by the experience gained in numbers of important works, that the only disturbing action of the industrial circuits upon telephone circuits arises from leakage to earth from the former. Induction only plays a very modest part. This view is shared by those who have been at the pains to verify it experimentally. To suppress all disturbance on a telephone circuit the industrial circuit must be perfectly insulated from earth in order to prevent these leakage currents, which give rise to sensible differences of potential between the earth plates of the telephone circuit, causing powerful parasitic currents to traverse it. This has been very well understood in those countries where the telephone is omnipotent as part of the administrative gear of the State. Thus the elaborate rules and regulations drawn up by the Swiss Telegraph Administration, under the law relating to the erection of telegraph and telephone lines, contain a clause specifying a minimum insulation for an industrial network, and makes it obligatory to test the insulation of every house installation before it is connected up. It is easy to obtain a good insulation on an electric lighting network; it is, indeed, necessary to the good working of the plant. Under these conditions a single-wire telephone system and an electric lighting continuous-current network can exist simultaneously without telephonic business being very much troubled.

It is altogether different when we come to the simultaneous existence in the same town of a telephone exchange and a system of electric tramways to which the current is supplied by wires. Tramways of this description may be divided into two categories: those in which the feeding circuit is entirely metallic, and those in which the earth or rail is used to complete the circuit. In the former case the disturbances experienced on telephone lines are largely due to the currents straying to earth through the motors, car frame and rails; a result which it is impossible to avoid. That this is really the cause is confirmed by the fact that the disturbance increases in strength in wet weather, when the insulation of the line and motors falls. At Montreux, for instance, where the 11-kilometre electric tramway is on the two-conductor system, with hollow overhead conductors and a sliding shuttle-shaped contact, parasitic noises due to the tramway currents are frequently observed. It is in fact quite easy to follow the course of the cars, and to note their speed, stoppages and startings. In the second case the action of the tramway current upon the telephone circuit is direct in the sense that the return of the current through the rails and earth produces differences of potential between the ends of the telephone lines near the tramway, and thus large parasitic currents are generated. These disturbances are much greater than the others, and it is very difficult to diminish them sufficiently not to interfere with the telephone service.

We can therefore assume, without fear of contradiction, that a telephone service is practically and commercially very difficult, if not impossible, in the case of a single-wire system existing in conjunction with an electric tramway system having a rail return.

There are two remedies: the tramway may be changed from the rail-return system to the complete metallic circuit, without touching the telephone system; or we may let the tramway alone, and change the telephone network into one on the complete metallic circuit system. There can be no hesitation in saying which course should be taken: the first sanctions the *status quo* and the stagnation of telephony; the latter is an enormous improvement in telephony, the most important, indeed, which remains to be carried out at the present moment. And while effecting an improvement, this solution of the question restores complete independence both to telephonic and industrial circuits. It should,

* From *L'Électricien*.

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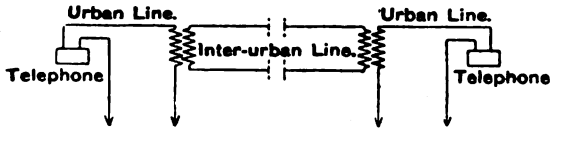
therefore, alone be allowed where a system of electric tramways is laid down near a telephone system.

Moreover, the introduction of twin wires should be considered, quite apart from all external disturbing causes, as an absolute necessity. The public should not cease to demand this improvement, for this supreme fact must not be lost sight of; it is impossible to get perfect telephonic transmission on a circuit of which the earth forms an integral portion.

This conclusion follows indeed from what has been said before, but it is strengthened by the following considerations called forth by the exigencies of interurban telephony. If the telephone did not at the commencement overstep urban limits it now no longer keeps within them. The telephone becomes every day more important as a means of long-distance interurban communication. A study of the statistics of interurban telephony shows the growing importance of this branch of telephony, both as regards the number of communications and as regards the receipts. We may boldly predict without fear of contradiction by events that the second decade of the telephonic era will be specially devoted to the development of long-distance communication; the first decade having witnessed the development of urban communication. The limits of this article preclude a proof of this assertion from the statistics of the countries in which the telephone service is most highly developed, namely, Sweden, Switzerland, and Germany.

Now interurban telephony is impossible without complete metallic circuits, at any rate in the case of long-distance lines; in fact, metallic circuits alone give us silent lines, and allow us to erect lines with many circuits. This last desideratum is of the utmost importance from the economical point of view. In Switzerland, for example, single-wire interurban lines have up till now been erected, the inconvenience due to parasitic noises being passed over. It has been necessary to run these lines along routes having no telegraph wires in order to avoid the induction from them. But at the present moment the majority of these circuits are too crowded, and the following dilemma arises:—Shall the new lines be run along roads not yet used, taking a circuitous route, or shall they be double wired? The first solution is evidently impracticable, since in the end the entire country would be covered with a serried network of telephone lines, both costly to maintain and to watch; and the prime cost would soon be higher than that of double-wire multiple-circuit lines run on the old poles.

Interurban circuits being on the twin-wire system, it necessarily follows that the same thing must be done for the town circuits, in order to avoid a double translation. Single-wire urban lines have to be joined to twin-wire interurban lines by means of translators, which are simply transformers, the secondary circuit of which is interpolated in the interurban line, the primary being in the subscriber's earth-completed circuit. The connection between two subscribers and an interurban line is effected, in fact, in the manner shown in the accompanying diagram. There are, therefore, two



transformations of the telephone current; and as each causes a deformation and a weakening of the electrical waves, the result is a distortion of the voice and a diminution in the volume of sound. Hence this device has given but indifferent results in practice, and absolutely cannot be considered as a solution of the problem of connecting single-wire urban to double-wire interurban lines. The only truly satisfactory solution is to adopt nothing but complete metallic circuits for all telephonic transmission.

Yet another decisive argument militates in favour of this improvement. Owing to the continual augmentation in the number of telephone subscribers the overhead telephone networks are becoming more and more crowded, so that in towns of any commercial importance telephone engineers are face to face with the absolute impossibility of connecting up fresh subscribers to their exchanges. It is necessary, therefore, to have recourse to underground telephone wires and to replace overhead wires by subterranean cables This change is also generally desirable in the case of the central portions of aerial systems, where the crowding of wires is often intolerable and in winter even dangerous, owing to the frequent breaking of the wires by the action of cold and rime. The fracture of a single wire frequently results in that of the neighbouring wires upon which it falls, and this naturally causes interruptions which it takes a long time to restore.

But multiple-conductor telephone cables do not give satisfactory results if used with single-wire circuits. Cables of this kind consist of a number of insulated wires covered with a conducting sheath, lead in the Berthoud-Borel and metallic foil in the Felten-Guilleaume cables, the whole being cabled together. The metallic sheathing of all these wires is connected to earth, and its object is to completely suppress mutual induction between the wires of the same cable. This result is only approximately obtained. When these underground lines become somewhat long the mutual induction of the neighbouring wires is far from negligible. On this account, it is no use thinking of employing these cables for extensive telephone systems. Recourse must be had to complete metallic circuit cables, in which the two wires of every circuit are twisted together so as to completely eliminate their mutual inductive action. Cables of this kind alone permit the establishment of extensive telephonic networks in a manner which shall assure a satisfactory service. This fact has, indeed, been recognised by the Swiss Telegraph Administration, which has substituted in some cases single-wire cables for cumbersome overhead wires, and which now seems anxious to adopt double-wire cables. Thus at Zürich at the present moment they are laying down several kilometres of underground cables having 300 separate metallic circuits; this decision naturally involves the complete transformation of the telephone network into a twin wire network, and the authorities are proposing to do this.

All the desiderata of telephonic traffic are summed up in the formula—exclude earth and employ complete metallic circuits. This transformation of the telephone circuits will not be carried out without considerable expenditure; but it must come, since it is imposed from a purely telephonic point of view, and it will be the last step in the progress of telephone exchanges. It is to be remembered that at the dawn of telephony, engineers, struck by the marvellous sensitiveness of the telephone, said, "Anything is good enough for the telephone." Insulation and high conductivity wire seemed useless, but we have gradually come back from this point of view; and now the greatest care is betowed upon the insulation of the circuits and the conductivity of the lines. Single and double bell insulators have replaced the ordinary mushroom insulators which were first employed. Copper and bronze wires have been substituted for iron wires, while the joints are now carefully soldered, a precaution at first considered unnecessary. Indeed, we are all crying, "Nothing is good enough for the telephone." In any case. what has been said above shows that every telephonic system that uses earth as an integral part of the circuit does not fulfil modern conditions, and ought to be considered as defective.

The electrical monopoly of the earth, which the Telegraphic Administrations of certain States have assumed, should be considered as an encouragement to the spirit of routine. Commercial men of all countries should raise their voices against this contention, all the more extravagant since telephonists without exception anticipate the introduction of twin wires; it is absolutely necessary to insist upon this improvement in telephonic systems from the present moment, since the longer we wait the more difficult it will be to carry out the change, owing to its costliness. No multiple switchboard should be introduced into an exchange without the system itself at the same time being transformed, even where underground wires are used.

The complete metallic circuit being imposed upon telephonic exchanges by the necessities of their business, there can be no question of imposing upon electric tramway promoters the conditions that they should not employ the rails as a return. The single-wire method of construction is the only one which is suitable for tramways in the vast majority of towns, where small first cost and regular working are of first importance. A complete metallic circuit for tramways increases the first cost by 50 per cent. In the case of aerial conductors (which I am alone considering) it also complicates the system, the double trolley being a very difficult business, especially at crossings where it causes numerous breakdowns. To decree complete metallic circuits for all electric tramways is tantamount to depriving a large majority of towns of this mode of locomotion, where it would otherwise be possible, without taking into account the fact that the leakage current to earth would in spite of the double circuit always be sufficiently strong with telephone earth returns, as in the case of the Vevey-Montreux tramway, to interfere with other lines.

There can be no question, therefore, about insisting upon electric tramways employing metallic circuits in order to avoid the necessity of introducing the same on telephone lines. The use of the rails as a return for tramway currents is advantageous from a financial point of view; andit would be out of the question to forbid it, with the sole object of allowing telephone companies to persevere in mistakes fatal to good working. The earth return is advantageous from the technical point of view, inasmuch as it considerably facilitates both the construction of the lines and their working; crossings in particular are much more easy to carry out, and the appearance is less distasteful. The accumulation of conductors at the junctions and crossings are not so great, without mentioning the fact that the poles can be lighter and more elegant. From the financial point of view the advantages are still greater, since, in addition to the fact that the constructive facilities result in appreciable economy, the suppression of the return wire in itself constitutes a great saving. These conclusions hold good for subterranean conductor electric tramways as well as other lines. This is not tanta-

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mount to saying that the electric tramway ought to be constructed without any precaution whatever. It is most important to secure good metallic contact between the rails in order to avoid sensible difference of potential between different points of the circuit. With this object it is good to lay along the rails a copper conductor making good contact with the rails at the fishplates. This method has given excellent results wherever it has been employed, as at Clermont-Ferrand and Sissach-Gelterkinden. The pole of the generator which is put to earth ought to be connected to this copper wire. This precaution is always necessary with earth return. The second precaution is good insulation of the line, which can be obtained with special oil or deep double bell insulators. Good insulation is necessary, by reason of the leakage which might arise without it, between the iron pillar and the conductor which it supports. Beyond this it is difficult to see what conditions can be imposed upon the electric tramway promoters.

There was at one time talk of employing a single large return wire as a common return for all the wires of a telephone exchange. Some satisfactory experiments have been made; and at the time when this idea was mooted I submitted the matter to calculation, and arrived at fairly satisfactory results, but which I have been unable to confirm by direct experiment. In spite of this, however, the employment of a common return for a telephone exchange cannot be generally recommended, owing to the complication of working which it would entail, a complication altogether out of proportion to the slight improvement which would be obtained in the working.

All that has been said seems to show sufficiently well that the following rule should be the basis of modern telegraphy:—All telephone lines should be constructed with complete well-insulated metallic circuits, and the earth should be completely excluded. When these conditions are fulfilled the disturbances produced by continuous electric lighting currents or the currents of electric tramways are completely annulled, a result which can only be arrived at in this way.

THE ELECTRICAL TRADE SECTION AND THE CHICAGO EXHIBITION.

The following circular letter has been sent to members of the Electrical Trade Section:—

LONDON CHAMBER OF COMMERCE,
Botolph House, Eastcheap, London, E.C., July 17, 1892.

Dear Sir: As you will no doubt observe from this week's issue of the Trade Papers, Mr. W. H. Preece, of the General Post Office, attended at the meeting of the Electrical Trade Section of this Chamber on Friday last, and gave reasons why the Section should endeavour to co-operate in the organising of a representative British Electrical Exhibit at the forthcoming Chicago Exhibition. The Society of Arts, as you are aware, are acting as the British Royal Commission for this Exhibition, and we are informed by Mr. Preece, as representing the Electrical Section on that body, that while other industries will send to the Exhibition the most magnificent display ever sent by this country to any home or foreign Exhibition, the electrical industry has up till now been an exception to the rule, and the articles to be exhibited are not considered to be anything like an adequate representation of the advancement which has been made in the application of electricity in this country during recent years, especially, too, as we believe the amount of capital invested in England has enabled developments to be made which have not as yet been equalled in any other country. For your information, I enclose a list* showing the firms proposing to exhibit, the articles to be exhibited, and the space occupied.

Hitherto, there has, we believe, been a disinclination to exhibit at Chicago, probably from a feeling of resentment in the first place to the McKinley tariff, and secondly because, apart altogether from this question, to exhibit there is not likely to result in developing any further trade with the United States. In regard to the first of these considerations, we would point out that if there were to be an entire absence of English exhibits, or even of electrical apparatus alone, visitors would seek for, and no doubt find, a reason for the absence of English exhibits in the McKinley tariff; but, as certain firms find it an absolute necessity to exhibit if they are to preserve the trade which they have already acquired with foreign countries, the question comes to be whether foreign visitors will not be entitled to regard the exhibits there as fairly representative of the state of the electrical industry in England. In regard to the second consideration, nearly all are agreed that the Exhibition will not be productive of any trade with the United States; but in view of what has just been said, is it not desirable, in the interest of British foreign trade in general, that the industry should combine to make a representative exhibit? Such an exhibit would impress foreigners with the progress which has been made in this country in electrical science, and might possibly result in inducing them to make application later, if need be, to English firms, instead of patronising nations who have created a better impression in consequence of a better display. Further, the various articles comprising the exhibit can be labelled prominently with the name of the makers, so that the exhibit will be personal as well as representative of the industry as a whole.

Mr. W. H. Preece suggests that this object might be accomplished by a certain number of firms combining as a syndicate to furnish a suite of rooms, and to have them decorated and lit up by electricity in the manner common to English houses. The expense would, of course, in this case be shared proportionately. If a response to this circular is received which would warrant our prosecuting this matter further, then the Chamber would make an effort to secure the co-operation of the Furniture and Textile Trade Sections in supplying furniture, carpets, curtains, &c., &c. In such an event the expense to each individual firm would, of course, be reduced proportionately. Mr. Preece has no doubt that the Royal Commission would be prepared to take charge of the exhibit, but possibly exhibitors would prefer to appoint some one to take charge of the exhibit who might be paid a commission on the sales.

Free space has been provided, and only 5,000 out of the 20,000 square feet provided for electrical exhibits has as yet been allotted. In order that we may know how far we are likely to be supported in endeavouring to carry out such a scheme as has been here indicated, I should be glad if you would fill up the enclosed form and return to me at your earliest convenience.—Yours faithfully, KENRIC B. MURRAY, Secretary.

[ENCLOSURE.]

(1.) Are you prepared to exhibit at Chicago on the lines indicated on the enclosed circular? (2) If so, what sum are you prepared to guarantee, it being understood that you would only be called on to subscribe proportionately, the proportion, of course, depending upon the number of firms coming forward? (3.) What would be the nature of your exhibit and the amount of space you would be likely to require?

* *See* p. 285 of last week's issue.

LEGAL INTELLIGENCE.

The Medical Battery Company v. Jeffery.

On Tuesday, at the Bloomsbury County Court, before his Honour Judge Bacon, the claim and counter-claim in the above-named action were heard. Mr. De Witt (barrister-at-law) appeared for the Company, and Mr. Lickfold (Messrs. Lewis and Lewis) appeared for the defendant.

The claim was £3. 5s., balance of £5. 5s., the price of an electric belt (Harness's patent) supplied by the plaintiff Company to the defendant; and the defendant, by way of counter-claim, sought to have an I.O.U. for £3. 5s. delivered up to him, and the sum of £2 cash returned to him on the two following grounds:—First, that he was induced to buy the electric belt through misrepresentation; and, secondly, that there was no good consideration for the contract into which he had entered with the plaintiff Company.

The following evidence was taken:—

Mr. FREDERICK THOMAS SIMMONDS, examined by Mr. De Witt, said he had been in the employ of the plaintiff Company for nearly seven years. He had had great experience in fitting trusses and dealing with hernia and strains. The defendant came to their establishment on May 9th, and saw one of the receiving officers. He was shown to the witness's consulting room. He said he had a sprain which he thought might develop into rupture. Witness examined him, and said the hernia was incomplete. Witness recommended the electric belt in order to decrease the pressure, and to give a tonic to the muscles.

Cross-examined by Mr. LICKFOLD: Witness said he had been employed by the plaintiff Company for nearly seven years. He began treating hernia after he had been with them for about three months. Before being employed at Harness's he was engaged in commercial pursuits. He had studied hernia all his life; ever since he was nine years of age. His "commercial pursuit" before he was employed by the plaintiffs was that of salesman in Oriental furniture in the West End of London. He did not acquire much knowledge of the treatment of hernia in selling Oriental furniture. But after being in the plaintiff's employ for three months developed into a consulting person. He had assistance from others. He was now one of the consulting officers. He did not send for one of the medical attendants because in matters relating to hernia his practice was far beyond theirs. He did not think it necessary to consult them except in a very complicated and abstruse case—and then they generally left it to him. The belt sold to and worn by the defendant weighed between 2lb. and 3lb. It was a proper belt for incipient hernia. There was electricity in it. The patient did not require more electricity than he would get out of the belt. Witness on being asked to pledge his oath that there was any electrical current in the belt, said that he had no knowledge of electricity.

Mr. LICKFOLD, addressing the Court, said the defendant was a cashier in the Union Bank, and having, as he feared, ruptured himself, his attention was attracted to an advertisement calling attention to the Electropathic and Zander Institute, 52, Oxford-street, where medical advice was given gratis. He asked to see a medical man. He saw Mr. Simmonds, and told him he was suffering from rupture. Mr. Simmonds examined him, and told him he was not so suffering, and added, "You must have one of our belts, and that will set you right." The defendant was fitted, and took a belt costing £5. 5s. Instead of doing good, the belt chafed the skin and caused an eruption, and the illness was so aggravated that the defendant consulted a medical man, Dr. Rowntree. After going through the facts, Mr. Lickfold said he should produce evidence to prove that these so-called electric belts were nothing else than fraudulent impositions. People were inveigled into this trap, and belts, which were absolutely worthless, were palmed on them, and they were ashamed to proclaim their

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folly by prosecuting the promoters of these impostures. But it was now time that it should be put a stop to. The learned gentleman submitted that there had been misrepresentation in this case, because Mr. Simmonds was not a qualified man, and because he misled the defendant by telling him that he was not suffering from hernia when he was so suffering. Then the defendant was entitled to have his money and I.O.U. returned to him, as he had not received any good and proper consideration for his money.

The defendant, Mr. D. JEFFERY, in examination-in-chief, said he was very pleased at being told he was not ruptured. He wore the belt for some time, and it gave him great pain. There was a downward pressure, and a lump formed in his groin—an external sore also formed. When he took off the belt he felt relief. He consulted Dr. Rowntree. He left off the belt entirely and wore a truss, which cost 12s. 6d. He was much better now. The doctor told him he was ruptured, and had been so for some time.

Cross-examined by Mr. DE WITT: Witness stated that he wore the belt for more than a week. He got so bad that when he moved he was in excruciating pain. He did not ask the price of the belt before it was fitted on, and had he known it was £5. 5s. he would not have purchased it.

Mr. WILLIAM GEORGE ROWNTREE, L.R.C.P., examined, said on May 23rd Mr. Jeffery called on him at his house. He examined him, and found that he was suffering from rupture. There was no doubt about the nature of his suffering. He had examined the belt, and he was of opinion that if it was fitted tight on a patient suffering from rupture it would aggravate the complaint. He had heard the defendant's evidence as to the swelling in the groin, and he thought that that swelling had existed for some time previous to witness seeing him. The belt would not be of any use to the defendant. He recommended a truss, and the patient was getting better.

Mr. T. E. GATEHOUSE said he was an electrical engineer. The belt in question had no electrical powers, and was utterly useless. As the belt was worn it never produced a trace of electricity. That morning he had made an experiment with the belt, so as to produce a small quantity of electricity. He took salt water, and moistened the two parts, and then he connected the copper and zinc with a galvanometer, and so he got a slight deflection of the needle of about 14 degrees. He then put the belt on his legs and on his arms, and the deflection was not in the slightest degree altered. That showed that when these belts were worn by any patient no electricity passed through the body in any way whatever, but only along the webbing of the belt and over the skin surface. Electrically these things were useless.

Cross-examined by Mr. DE WITT: Witness said that zinc and copper were used in generating electricity. The belt would produce no current at all as the defendant wore it. The circuit was not completed. He saturated the belt with salt water and then he got a small electrical current. He said there was a current if properly connected up, but the current would not go through the body—it was the webbing and skin and not the body which formed the internal circuit.

This concluded the evidence.

Mr. DE WITT contended that though there might have been an error in judgment on the part of Mr. Simmonds, there had been no wilful misrepresentation—such as according to the ruling in the case of "Peek *v.* Derry," would entitle the defendant to have his contract rescinded and his money returned. He also submitted that there had been no failure on the plaintiff's part to give the defendant consideration for his money.

His HONOUR, in giving judgment, said: In this case the plaintiff sued for the balance of the purchase money of an electrical appliance, and the defendant by his counter-claim said, "I want to get back the money which I paid on account, either on the ground that I bought it on the misrepresentations made to me by your agents, or on the ground of a failure of consideration." His Honour was of opinion that it was clear on the evidence that the defendant went to the plaintiff's establishment and asked to see a qualified doctor. That was uncontradicted. The defendant had shown that the gentleman whom he saw (the gentleman who called himself an "expert;" a gentleman without any medical education, or education in this matter, except having studied the best works on the subject since he was nine years of age), and when he asked for a truss, recommended him something which he said was better. The defendant had shown that this gentleman told him he was not suffering from rupture, but only from the beginning of rupture. I have no doubt from the evidence Mr. Simmonds said to the defendant: "I am happy to tell you you are not ruptured." But that was not the fact, the defendant was ruptured, as his Honour could not help believing from the evidence of Dr. Rowntree, who said: "From my observation, and from the symptoms described to me by the defendant, I am satisfied that the rupture had existed three months before I saw him on May 23rd." Then was the thing which the defendant received the thing which he asked for? His Honour would not enter into the merits of an electrical appliance which he did not understand. Mr. Gatehouse's evidence as to the electrical volume might be right or wrong—he did not know; but this belt was the thing put on the man when he was ruptured, and the man was persuaded to buy it upon the representation that he was not ruptured. He went for a truss. He was told, "You do not want a truss." This is a representation made by a man who had not taken the trouble to qualify himself, and who ought not to have made any representation at all. That was the representation which led to the contract, a contract without any good of any sort to the defendant, and it must be voided. There must be judgment for the defendant on his counter-claim, and his £2 must be returned to him.

Mr. LICKFOLD applied for costs on the higher scale.

His HONOUR refused the application. Judgment accordingly.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 2, 1892.

Electric Lighting at the Chicago Exhibition.—As announced in a former letter, the contract for lighting the World's Fair grounds was awarded to the Westinghouse Electric and Manufacturing Company. Mr. Westinghouse, through his individual efforts, secured this contract, taking it at a very low rate in sharp competition with the General Electric Company. At the time the bid was made Mr. Westinghouse agreed to furnish a bond for $500,000 to assure the authorities that the contract would be carried out. The first bond furnished was rejected, as it appeared on investigation that the Company furnishing the bond had just been organised with a capital stock of $500,000, and it appeared to the authorities that the Company had been organised for this purpose. It is now announced, however, that the bond is guaranteed by an indemnity bond signed by August Belmont, Charles Francis Adams, Brayton Ives, Marcellus Hartley, and George Westinghouse, jun.; this has been accepted as satisfactory. It is stated that the contract for the necessary wiring has already been placed by the Westinghouse Company, and that Mr. E. E. Keller has been placed in charge of the work. Mr. Keller resigned his position as assistant to Chief Barrett to take charge of this work.

Allotment of Space at the Chicago Exhibition.—The allotment of space in the different departments of the World's Fair began on July 1. Applications have been received for space in the electrical building covering twice the floor space at command, so that very few, if any, of the exhibitors will be given as much space as they have applied for. The authorities are about to carry out some tests of different styles of electric, steam, and naphtha launches for use on the lagoons in the Exhibition grounds.

Telephone Statistics.—The first publication of the Census Department of Statistics relating to the electrical industries has just appeared in the form of a special census bulletin. This refers to the telephone statistics of the country, and gives detailed comparisons regarding the cost and operation of telephones in 1880 and in 1890; one of the most interesting points noted in this publication is that while the gross earnings per subscriber have increased 12·75 per cent., and the gross expenses per subscriber have remained about constant, the net earnings per subscriber have increased 54·68 per cent. At the same time the aggregate dividends per subscriber have increased 123·04 per cent., and the surplus per subscriber has increased 5·63 per cent. The percentages of increase and decrease from 1880 to 1890 in those items of essential interest to the public are shown in the following summary:—

Summary showing Percentages of Increase or Decrease from 1880 to 1890.

	Increase (per cent.)		Decrease (per cent.)
Number of companies, firms, and persons reporting	—	...	64·19
Interest-bearing and profit-sharing investment	395·30	...	—
Interest-bearing and profit-sharing investment per mile of wire	—	...	29·34
Interest-bearing and profit-sharing investment per subscriber	5·30	...	—
Net earnings per mile of wire	3·60	...	—
Net earnings per subscriber	54·68	...	—
Number of exchanges	183·98	...	—
Miles of wire per exchange	145·57	...	—
Number of subscribers per exchange	64·86	...	—
Number of *employés* per exchange	—	...	12·50
Miles of wire	600·81	...	—
Miles of wire per subscriber	49·30	...	—
Number of subscribers	369·61	...	—
Number of *employés*	158·99	...	—

Railway Motor Tests.—One of the most interesting Papers read at the recent meeting of the American Institute of Electrical Engineers was that on railway motor tests, by Prof. G. D. Shepardson, of the University of Minnesota. The Paper contained a large number of very interesting results obtained by tests upon railway motors, using the two most common methods of regulation, namely, commutating the field and using a dead resistance. One of the most surprising features shown by the

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curves which he exhibited was the violent fluctuation of current when something over 200 cars were in operation. It has generally been supposed that increasing the number of cars smoothed out the irregularities of the load diagram; but it appears that in this case the main ammeter indicated fluctuations from 1,400 to 2,700 amperes, while the greater part of the fluctuations were between 1,800 and 2,400. Prof. Shepardson also gave what is probably the first explanation of the phenomena known among railroad men as "bucking" of the motors.*

NEW YORK, *July* 8, 1892.

The Marking of Foreign Goods at the Chicago Exhibition.—Considering the fact that much interest has been aroused in England and other European countries concerning the recent order issued by Director-General Davis, of the World's Fair, to the effect that foreign exhibitors could not be permitted to mark their goods with the selling price, minus the duty, it will be a matter of considerable surprise that a circular has now been promulgated of an exactly opposite order. This circular should set at rest all doubts in regard to the privilege of marking the selling price of their goods by foreign exhibitors, both with and without the duty. The part of this circular which is of most interest reads as follows:—"Foreign exhibitors to the World's Columbian Exposition will be permitted to state upon placards attached to their exhibits the prices at which said products shall be sold at place of manufacture, and also the price in bond and out of bond, or exclusive and inclusive of the customs duties in Chicago." The letter states that the former ruling in this matter was a mistake, and is, therefore, revoked. This circular letter has been sent out to foreign consuls, and is to be given as much publicity as was given the former incorrect ruling in the same case.

The New York Rapid Transit Scheme.—The Supreme Court of New York State has approved the report of its sub-committee, authorising the Rapid Transit Commissioners to go ahead with the building of the rapid transit road which has been planned for this city. This ruling merely gives the Commissioners authority to proceed with their work, provided, of course, the necessary capital is forthcoming. The general outline of the proposed plan is already familiar to your readers. It contemplates the construction of an underground road in the form of an immense Y, the two arms being eight or ten miles in length, and the stem about four miles. In regard to the motive power to be used no specific arrangement was called for, except that the report limited the contractor to the use of one system, electricity or otherwise, not requiring combustion in the tunnel. Whether or not the progress of the work will be hindered by unexpected trouble in raising capital for the enterprise remains to be seen. It is rumoured that complications have already arisen, owing to projected improvements and extensions of the existing elevated railroad system. This would interfere, it is thought, very materially with the work of securing the necessary capital.

CORRESPONDENCE.

ELECTRIC LIGHTING IN SWITZERLAND.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We send you a few supplementary notes on details of the Geneva Central Station, published in your issue of July 1st.

At the end of 1891 the Société d'Appareillage Électrique and the electric works of Cuénod, Sautter, and Co., owners of the Thury patents, were united under the name of Compagnie de l'Industrie Électrique; and from this period the electric lighting of Geneva has received a good deal of development and improvement. There is only one difficulty opposing the further increase of the central station—the society is forbidden to furnish electricity as a motive power, since the distribution of water under pressure for supplying turbines is in the hands of the municipality.

At the central station of the island the dynamos are not driven by turbines taking their water directly from the river, but by the high-pressure service. The Compagnie de l'Industrie Électrique is completing the building containing the hydraulic plant, and known at Geneva as Les Forces Motrices, as an alternating-current central station. There is only a 50 H.P. alternator at work at the present moment. Two others, one of 100 and the other of 200 H.P., are to be erected as soon as possible. The transformers are enclosed in cast-iron boxes, fixed on cast-iron stands.

The forthcoming installation of Chevres, utilising the waters of the rivers Rhone and Arve, deals with 8,000 H.P. exclusively used for driving dynamos or alternators, the choice of the system of distribution having not yet been decided upon. Several schemes have already been brought up, amongst those one on the five-wire system, adapted for the supply of the motive power to the numerous tramways of the town at 500 volts pressure, and another one with alternators and double transformation. The Saleve Electric Railway is approaching completion, and will probably be open to the public in about two months' time.—Yours, &c., LOUIS GOICHOL.

Cie. de l'Industrie Électrique, Geneva, July 8, 1892.

MR. JACOB BRETT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Council of the Institution recently brought to the notice of the First Lord of the Treasury the strong claims which, in their opinion, Mr. Jacob Brett has on the Government for some further pecuniary aid in his old age; and I am very happy in being able to inform you that their representation has resulted in a grant of £200 having been made to him from the "Queen's Bounty" on the recommendation of Mr. Balfour.

As you will probably be glad to notice this matter in your Journal, I venture to remind you that, in Part 95 of the Proceedings of the Institution, pp. 510-515,* you will find an admirable account by Mr. Latimer Clark of the important part taken by Mr. Brett and his brother, Mr. J. W. Brett, in the introduction of telegraphy, both land and submarine. In fact, to those gentlemen seems undoubtedly to belong the distinction of being the real pioneers of oceanic telegraphy.

It is a somewhat curious and in some sense a melancholy coincidence that this second mark of recognition by the British Government of Mr. Brett's services should have been conferred upon him within a few days of the lamented death of Mr. Cyrus Field, to whose indomitable energy the practical realisation of the Messrs. Brett's scheme for the establishment of an Atlantic telegraph was undoubtedly greatly due.—Yours, &c., F. H. WEBB, Secretary.

The Institution of Electrical Engineers,
London, July 19, 1892.

[* This account was also published in *The Electrician*, Vol. XXVIII., p. 64.—ED. *E.*]

THE DIMENSIONS OF PHYSICAL QUANTITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I infer from your Note that in the endeavour to sum up concisely I have failed quite to convey my meaning. Prof. Rücker and Mr. Williams treat certain coefficients as concrete quantities. This they call taking account of the "suppressed dimensions" of μ and k. My contention is that the symbols of dimensional formulæ are numerical, not concrete quantities; and in the sentence "we prefer to suppress them all" I only meant to express that contention in Prof. Rücker's phraseology, not to suggest that the dimensional formulæ should be abandoned as useless. The more we use symbols as "thinking machines," the more need that the symbols and operations should be carefully defined, otherwise their "thoughts" are apt to be illogical.

I open my letter again to enclose an extract from the preface to a well-known treatise on Natural Philosophy, which seems to confirm the "disputable opinion" on which you comment:—

"We believe that the mathematical reader will especially profit by a perusal of the large-type portion of this volume, as he will thus be forced to think out for himself what he has been too often accustomed to reach by a mere mechanical

[* An abstract of this Paper will be found on page 303 of the present issue.—ED. *E.*]

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application of analysis. Nothing can be more fatal to progress than a too confident reliance upon mathematical symbols; for the student is only too apt to take the easier course, and consider the *formula* and not the *fact* as the physical reality."—Yours, &c., W. M. M.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In "W. M. M.'s" interesting article on Mr. Williams' Paper on the "Dimensions of Physical Quantities," there occurs the following statement: "What we get out [of the electrical and magnetic dimensional formulæ] changes every day, but at present it includes that *electricity is ether*. . . ." Is it the case that any such deduction can be drawn from the study of these formulæ? In common with, I think, many other students whose mathematical equipment does not allow of their examining such questions very closely for themselves, I have understood that mathematical reasoning no more justifies using electricity than light as a synonym for the ether. If I am wrong I should be very glad to be corrected.—Yours, &c., E. M. C.

THE GREATHEAD SYSTEM OF TUNNELLING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to my Paper on Electric Traction, read before the Tramways Institute of Great Britain and Ireland on the 28th ult., and published in your issue of July 1st, my attention has been drawn by Mr. Greathead, M.I.C.E., to the statement that the "system of tunnelling is somewhat novel, and was introduced into this country by Mr. Greathead," is an error. Under date of 12th inst. Mr. Greathead writes me as follows:—"You are in error in supposing that the system of tunnelling with a tubular shield was first suggested in America. Beach's American patent was taken out when the Tower Subway (begun in 1868) was more than half driven under the Thames, and long after the shield used in that work had been described and illustrated in English journals (facts which must have been well known to the editor of the *Scientific American*)."

Kindly insert this letter in your next issue, and oblige, yours, &c., G. A. GRINDLE.

P.S.—I may add that the statement in my Paper above referred to was taken from the records of the Patent Office.

7, and 8, Great Winchester-street, E.C.,
July 14, 1892.

TRADE NOTES AND NOTICES.

Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.

TENDERS INVITED.—The Secretary of the Kildare-street Club, Dublin, is open to receive communications from firms wishing to be invited to tender for the installation of the mains and some of the fittings required for the electric lighting of the club. These communications must reach the Secretary on or before Thursday, the 28th instant (noon). Other particulars will be found in our advertising columns.

——— The Hull Corporation are prepared to receive tenders for wiring the Town Hall for electric lighting. Further particulars are given in our advertisement pages, and all other details may be obtained at the Borough Engineer's office, Town Hall, Hull. Tenders have to be in before 10 a.m. on Friday, August 5th.

——— The Gas Committee of the Leicester Corporation will receive and consider schemes, together with tenders, plans, and specifications, for the supply of electricity to their "limited area" in the centre of the town. Plans of the town and of the area to be lighted and all other particulars can be obtained from the Corporation's Engineer, Mr. Alfred Colson, M.I.C.E., at the Gas Offices, Millstone-lane, Leicester. Further particulars will be found in our advertising columns. Plans, &c., are to be in by Thursday, the 8th September next.

——— The Uxbridge Local Board invite tenders for the providing and fixing of an electrical tell-tale with electrical appliances and underground wire between their waterworks and reservoir, about 1¼ mile apart, to indicate at all times the depth of water in the reservoir. Particulars may be obtained of the Surveyor, to whom tenders are to be sent by the 31st inst.

APPOINTMENT VACANT.—The Commissioners of Hove require a competent electrical engineer to supervise the laying of their electric light mains and erection of plant, &c. Further particulars are given in our advertising columns.

FOR SALE.—Messrs. Wheatley Kirk, Price and Goulty have for sale (a bargain) newly-erected engineering works, with old-established connections, siding to main line, at the present time making fair profits. Further particulars are given in our advertising columns.

SALES BY AUCTION.—Messrs. Percy Matthews and Matthews announce the sale on Thursday, July 28th, at 17, Princes-street, Hanover-square (one o'clock) of the electrical plant, stock-in-trade and fittings of an electrical engineer, comprising a variety of lamps, holders, plugs, switches, &c., &c. Further particulars are given in our advertisement columns.

——— Messrs. H. N. Newton and Co. offer for sale on Monday next, July 25th, the valuable plant and machinery of a chemical electrician, on the premises, 85, Arlington-street, New North-road, London, N. Further particulars are given in our advertisement columns.

PERSONAL.—Mr. A. Calder has been appointed the National Telephone Company's London manager, in place of Mr. Dane Sinclair, who is now engineer-in-chief of the Company.

——— Mr. G. H. Nisbett and Mr. F. H. Jackson have been appointed second and third engineers respectively to the City of London Electric Lighting Company (Limited). Mr. Nisbett was formerly with Messrs. Paterson and Cooper; and Mr. Jackson with Messrs. Willans and Robinson (Limited), and were both, until recently, members of the staff of Major-General Webber.

MESSRS. GEORGE NORTH AND CO.—This firm have been appointed London representatives of Messrs. H. E. Hodgson and Co., of Cleckheaton, near Leeds, manufacturers of engineers' machine tools, &c.

EQUITABLE TELEPHONE ASSOCIATION (LIMITED).—A meeting of the shareholders in this Association (in voluntary liquidation) will be held at the office of Mr. C. L. Nichol, 1, Queen Victoria-street, E.C., on August 15th, at 12 o'clock, to receive an account of the winding up.

ALLCHIN, LINNELL AND CO. (LIMITED).—Proofs of debts in this liquidation must reach the liquidator, Mr. C. J. Stewart, 33, Carey-street, W.C., by August 15th.

FROUDE-HURRELL TORPEDO COMPANY (LIMITED).—This Company was on Friday, the 8th inst., ordered to be wound up, on the petition of Mr. Hurrell, a creditor.

MESSRS. DRAKE AND GORHAM.—Amongst the contracts recently obtained by this firm for the installation of the electric light, &c., are those for the London Assurance Corporation, Royal Exchange, E.C.; the Bank of Egypt, Old Broad-street, E.C.; and the Law Union Fire Office, Chancery-lane, W.C.

MESSRS. EVANS, STEWART, PALMER AND CO.—Amongst the recent installations effected by this firm is one at Messrs. Herring and Lake's, Great Portland-street, W.

MESSRS. E. J. DUGDILL AND CO.—This firm have just secured the contract for lighting the large entrance hall and new extensions at the City Art Gallery, Manchester.

MESSRS. RICHARD CRITTALL AND CO.—This firm have recently, under the personal direction of Mr. J. A. Phillips, their electrician, installed the electric light at the offices of the *Local Government Journal*, London. The current is supplied from the Salisbury Hotel installation, there being altogether about 600 incandescent lamps; Elwell-Parker dynamos, driven by two Marshall's 20 H.P. compound stationary engines, being used. Over 100 storage cells have also been provided.

HOVE ELECTRIC LIGHT COMPANY.—The Electric Light Committee of the Hove Commissioners have recommended that, as soon as certain preliminaries have been carried out, the seal of the Board should be affixed to the deed of transfer of the Provisional Order, &c., to the Hove Electric Light Company.

WHITEHAVEN.—Dr. Hopkinson, F.R.S., has just sent in his report on the electric lighting of Whitehaven to the Trustee Board. Dr. Hopkinson, in this report, calculates that electricity can be supplied at Whitehaven at less than 5½d. per unit, which is the comparative price of gas, which in Whitehaven is reported to be of inferior quality. The estimated outlay is £12,430, and the annual charges for maintenance and working £1,947. 10s., from which the probable receipts are estimated to amount to £2,606. The report is an interesting one, and appears in full in the *Cumberland Pacquet* of the 14th instant.

ST. HELENS.—A trial of the new electric lighting arrangements at the Town Hall and municipal offices took place on Monday last, July 18th. The installation consists of 338 lamps. The whole of the plant has been supplied by Messrs. Bumsted and Chandler, and the wiring arrangements have been carried out by Messrs. J. D. F. Andrews and Co. The total outlay has been about

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£1,500, and it is estimated that the cost will be less than that of the gas, and that a distinct saving will result to the ratepayers.

ABERDEEN.—The Gas Committee of the Aberdeen Town Council have recently purchased for £1,900 the large building known as the Bon Accord Mills, with the intention of utilising it in connection with the supply of electric light to the city when the Corporation take that subject in hand.

YARMOUTH.—At the last weekly meeting of the Town Council the Electric Lighting Committee presented their report containing the conditions and instructions for fitting up the electric lighting installation. A tender was read from Messrs. Crossley Brothers offering to instal the electric light on the Marine Parade for £250 per annum. After some discussion, however, the Council decided not to entertain the matter for the present; it being finally agreed to consult Mr. W. H. Preece in the matter.

SOUTHAMPTON.—At the last meeting of the Town Council it was notified that the Local Government Board would hold the usual inquiry in respect to the application of the Council to borrow £650 for electric lighting purposes.

GRIMSBY.—At the last meeting of the Town Council the question of the electric lighting of the Town Hall was discussed, and the Chairman remarked that the cost of the electric light compared with gas showed a distinct saving.

ELECTRIC LIGHT FOR RAILWAY STATIONS.—The Caledonian Railway Company have been granted permission by the Edinburgh Dean of Guild Court to erect electric light appliances at their Princes-street Station.

HANLEY.—At a meeting of the Town Council on Tuesday the General Purposes Committee recommended that the Borough Surveyor be requested to prepare a report on those tenders for electric lighting which utilised a site on the canal side for the central generating station, and that the Borough Surveyor obtain from the different firms tendering for the street arc lighting such explanations and prices as would enable them to be placed on an equal footing.

HECKMONDWIKE.—An electric lighting scheme has been prepared under the direction of Mr. Hutchinson, C.E. It is to be an overhead system, with both arc and incandescent lights. The scheme embodies three sets of compound engines and dynamos, of which two sets only are required for an output of 1,000 lights, one set being kept in reserve, and two boilers are provided. The estimate of the cost shows the initial outlay to reach about £4,450, whilst interest, depreciation, and maintenance are put down at £1,048 per year. The estimated annual revenue is £1,432.

HOTEL LIGHTING.—The new Royal Palace Hotel, at Kensington Gardens, which is in course of construction by Messrs. Perry and Co., at an estimated cost of about £200,000, will be lighted throughout by electricity. It is expected that the hotel will be opened about February or March next.

LAUNCESTON (TASMANIA).—The City Council of Launceston have adopted a report favouring the lighting of the city with the electric light.

NEW JOURNAL.—Under the title of *Transport* a new journal has been started, dealing with docks and harbours, canals and railways.

EXHIBITION.—There is to be a Distillers', Brewers', Mineral Water Trades' and Appliances Exhibition at the Rotunda, Dublin, from August 15th to 27th. Firms desirous of exhibiting are invited to apply to the Secretary, at 69, Lower Gardiner-street, Dublin.

KING, MENDHAM AND CO.—On Saturday last the employés of this firm had their annual outing at Plymouth. Between 50 and 60 sat down to dinner. The firm defrayed all the expenses of the excursion.

STAMP DISTRIBUTION.—It will be remembered that some time ago a syndicate was formed for the purpose of floating an invention for the automatic distribution of stamps in connection with street pillar-boxes. Yesterday (Thursday) a gathering of press-men, and of gentlemen interested in the question, took place at the Cannon-street Hotel, E.C., and the latest form of the automatic stamp distributor was shown. It is intended to float a company to place this machine upon the market, and it is claimed that so self-evident a public convenience must have considerable success; certainly those present were satisfied of the capabilities of the machine to perform the functions for which it is intended, and it now seems only essential to success to obtain the full approval of the Postmaster-General. It may be that this approval has been already obtained, but no indication was given at the meeting that this was the case.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.—The tenth annual edition of the above well-known annual is on sale, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (a few countries excepted), post free, 8s. 10d. A digest of the contents will be sent on application.

BOOKS, &c., RECEIVED.

"School of Mines Quarterly." April, 1892. (New York: Columbia College.)

"Notes on Design of Small Dynamos." By George Halliday, Whit. Sch. (London: E. and F. N. Spon.)

"Das Räumliche Wirken und Wesen der Elektrizität und des Magnetismus." By Prof. Max Möller. (Hanover-Linden: Manz and Lange.)

"Telephones, their Construction and Fitting." By F. C. Allsop. Second edition. (London and New York: E. and F. N. Spon.)

"Tourist Guide to the Continent." Edited by Percy Lindley. (London: Great Eastern Railway Company.)

"Transactions of the Canadian Institute." April 1892. (Toronto: The Copp Clark Company.) Price $1.

"A Dictionary of Electrical Words, Terms, and Phrases." By Edwin J. Houston. (Second Edition. Rewritten and greatly enlarged.) (New York: The W. J. Johnston Company, Limited. 1892.)

COMPANIES' MEETINGS & REPORTS.

African Direct Telegraph Company (Limited).

The following is the report of the Directors, to be submitted to the ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., to-day (Friday), the 22nd inst., at 11:30 a.m.:—

The income for the year ended December 31, 1891, amounted to £53,021. 11s. 11d., consisting of £33,444. 6s. 4d. from traffic, £19,000 from subsidy, £577. 5s. 7d. from bank interest, rents and transfer fees. The working expenses, interest on debentures, sinking fund, and income-tax amounted to £41,281. 19s. 7d., leaving a balance of £11,739. 12s. 4d.; to this is added £1,023. 0s. 6d., brought forward from December 31, 1890, making a total of £12,762. 12s. 10d. A dividend of 4s. per share, amounting to £4,720, has been paid in respect of the half year to June 30th, leaving the sum of £8,042. 12s. 10d. to be dealt with Of this the sum of £3,000 has been transferred to the reserve fund; and the Directors now recommend the declaration of a dividend of 4s. per share to December 31, 1891, which will amount to £4,720, leaving a balance of £322. 12s. 10d. to be carried forward.

In accordance with the provisions for the repayment of the debentures, 549 bonds, representing £54,900, were drawn on May 5th last for payment at par on July 1st instant.

The Accra-Lagos cable referred to in the last report as having been interrupted on July 2, 1891, was successfully repaired by the Eastern Telegraph Company's s.s. "Amber," on August 1st following. The cause of the break is believed to have been due to suspension and a slight subsidence of the bank upon which the cable was laid. On October 5, 1891, a fault appeared in the Lagos-Brass cable, and was subsequently removed by the s.s. "Mirror," belonging to the Eastern Telegraph Company.

In accordance with the provisions of the Articles of Association, two of the Directors, Sir James Anderson and the Hon. W. St. John F. Brodrick, M.P., retire by rotation, but offer themselves for re-election. The Auditors, Messrs. Deloitte, Dever, Griffiths and Co., also offer themselves for re-election.

United River Plate Telephone Company (Limited).

The following is the report of the Directors, to be presented to the shareholders at the ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E.C., on Tuesday next, the 26th inst., at 3 o'clock:—

After payment of all expenses in the River Plate, debenture interest and all London charges, the profit at par of exchange is £30,069. 7s. 11d. on the Company's operations during the year ended March 31st, to which has to be added the sum of £2,037. 2s. 6d., brought forward from last year, making a total of £32,106. 10s. 5d.; from this has to be deducted the loss on exchange of £31,741. 0s. 8d., leaving a balance of £365. 9s. 9d., to be carried forward to the credit of profit and loss account for the current year. As shown in the balance-sheet, the capital expenditure during the year amounted to £1,008. 18s., as against £3,096. 10s. 10d., in the previous twelve months, and £12,772. 8s. for 1889-1890. The loss on exchange, £31,741. 0s. 8d., represents nearly 11 per cent. on the Company's paid-up share capital. The working expenses in the River Plate amounted at par of exchange to £58,618. 9s. 8d., against £56,941. 1s. 9d. during the previous year; this increase is mainly due to the augmented cost of materials, cartage, gas, and other expenses, owing to the depreciation of the paper currency. The London expenses were £1,638. 2s. 5d., against £2,732. 14s. 9d. for 1890-1891.

The Directors are glad to state that, since March 31st last, the business of the Company has improved in sympathy with the better condition of affairs in the Argentine Republic; it is expected, therefore, that the working for the current year will be much more satisfactory than for the year now under review.

Under the Articles of Association, Mr. George Cooper and Mr. Alfred Le Rossignol retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Brothers and Co., also retire, and offer themselves for re-election.

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Edison and Swan United Electric Light Company (Limited).

The annual meeting of the shareholders of this Company was held on Tuesday, at the City Terminus Hotel, Cannon-street, under the presidency of Mr. James Staats Forbes.

The SECRETARY (Mr. H. Charles Gover) having read the notice calling the meeting, the Directors' report was taken as read.

The CHAIRMAN said: I have had occasion before to call attention to the conditions of a Company like this, where circumstances operating in its interests make it expedient that the accounts should be stated in a manner rather more general than in some other companies which have a statutory form of account. I suppose, as the period arrives when our patents are running out, that reticence becomes even more necessary than in our earlier stages, and that is why these accounts are so brief in statement, and are confined to so few elements as compared with the accounts of some other public companies. Of course, the essence of all these reports is what profit has been made and how do we propose to divide it. I want to remind you of the peculiar position of this Company, and why, however satisfactory the result as shown upon a particular year may be in the distribution of dividend, it is necessary to bear in mind that there are some considerations acting rather in depreciation of that dividend. For instance, we shall to-day propose to divide such an amount of the profit realised in the year as with the provisional dividend paid six months ago will amount to 18 per cent. Last year we paid 17 per cent., the year before we paid 15 per cent., and in 1889—our first dividend paying year—we paid 10 per cent. Nothing is so readily excited as the cupidity of mankind; and as our business is being watched by a great many outsiders who, when it becomes an open business, will be ready to launch upon it in competition with us, it is just as well to bear in mind that for the five preceding years of our existence—the years prior to those which I have referred to—we paid no dividend at all; and perhaps it may qualify, not our satisfaction, but the aspirations of some other people to know that, notwithstanding we propose to pay this dividend to-day, really over the whole nine years of our existence the aggregate amount divided by us has only reached the moderate return of 6½ per cent. It is just as well that that should go forth to the outside world, because we know that there is a disposition on the part of the public themselves—the consumers—to think themselves aggrieved when the Company who manufactures what is consumed appears to be paying a considerable dividend. There is also the other influence—the cupidity excited to enter into the competition upon the theory that it must be a gold mine. Now, as to the accounts themselves. I had better take you through what is called the profit and loss, or the working account. It is very simple, and consists of only three or four heads. We begin every year, of course, with a large stock of lamps and material in anticipation of the requirements of the current year. The amount of that stock carried forward from year to year is a matter of some importance in forming an opinion as to the position of the Company. It may be too large or too small. If it is too small the Company may be placed at a disadvantage in the event of there being a sudden call for lamps—a sudden growth in the demands for them; or it may be too large, and involve the locking up of more than the necessary capital invested in the stock. Well, on July 1, 1891, we brought into the account stock of the value of £59,308. That is made up largely of lamps and of platinum, and other materials in hand. During the year, to keep abreast of the consumption, notwithstanding the possession of a large stock, we have spent in wages, purchases of material, &c., £59,001. That is the bare cost of the lamps, &c., produced at the factory—the mere mechanical part of producing the material and working it up into the production of so many lamps. Then come the whole of the administration expenses—the various heads of departments, the Directors, and all that machinery representing in a public company what the brains and directing influence of a partner or partners represent in an ordinary firm. A small amount is put down for depreciation of plant, &c., which, according to our judgment, is sufficient. On the other side of the account it is stated that the sale of lamps, &c., has produced £166,349; interest is put down at £473, and the stock on hand when we emerged from last year amounted to £45,225. Of course the difference between those two aggregate amounts is the balance of profit to be dealt with for the year, and that amounts to the respectable sum of £74,810. Now, what I want rather to call attention to is that this account is satisfactory in the sense of having diminished, and considerably diminished, the amount of money which is locked up in stock; and I think I may say that that is so without at all fearing the question upon the other possibility—that there is not stock enough on hand to meet any sudden emergency. I think we may say that to that extent our position is a little more wholesome than it was this time 12 months ago. We have produced that state of things by dealing fairly liberally with the elimination from the accounts of stock which had become more or less effete; in fact, we have written it down. Some considerable portion of it has gone to make up the increased income derived from sales, but a not inconsiderable portion of the difference has gone to writing down the value of the stock on hand carried forward into the account this year. I think you will consider that that is a safe and prudent thing to do. With reference to the sales, the large sum of £166,349 is not made up exclusively of the sale of lamps, because for the last two or three years we have been manufacturing fittings which are an adjunct to the lamps. Lamps are very delicate and wonderful instruments, but they require to be fitted in a variety of ways, according to the taste and ideas of the consumers; and we were driven to manufacture fittings, first of all because the holder of the lamp, which has become by the process of invention a part of it, was a very delicate operation, upon which a good deal of the convenience and use of the lamp depends, and we found we could do it better than anyone else. We therefore secured certain patents for fittings, and we are manufacturers and licensors. We have also a great many respectable firms in this trade—people who were gasfitters have become also electric light fitters, and we found it convenient to give them the opportunity of manufacturing fittings themselves if they chose. They do this on the theory of a royalty; and from the profit on the fittings we manufacture, and the royalties paid by these licensees, we receive a considerable annual sum, the advantage being that whereas the lamp patent will expire at no very remote date, the patents for these fittings and inventions run on for many years, and will afford us during what may be called "the protected period" a very considerable and growing annual profit. As to the balance of £74,810, we have already distributed in the course of the year a considerable portion of that in the nature of a dividend, and we propose to apportion the remainder of it so as to produce this 18 per cent. for the year. In order that you may understand that, I must refer you to paragraph 2 of the report, which is somewhat long-winded, and is somewhat complicated. It only repeats, however, what I have already told you—that the dividend of the particular year being limited to 7 per cent., all the rest of the profit goes in aid of those years during which no dividend was paid, because the 7 per cent., according to the contract between the partners, was to be cumulative. In addition to the capital on which this is divided, we have £117,000 of Deferred shares, representing Mr. Edison and his friends' proportion of the capital in this business—the consideration, in fact, for his patents and so forth. He has never received anything at present, nor can he or those who hold these shares receive anything until the shareholders of the Company—the A shareholders—have received 7 per cent. not only in respect of the current year, but in respect to all past years; and now, as you see by paragraph 2 of the report, we have wiped out everything up to the 30th June, 1888. We still have on that account a considerable sum to meet out of the profits of future years before the Deferred shareholders get anything. The appropriation of the balance of £74,810 is shown in the statement below the balance sheet. You see from that statement the profit brought down from the working account which I have just mentioned. The dividend for the year ended the 30th ult., at 7 per cent. per annum, is £24,743; the payment of cumulative preferential dividend on the A shares for the year ended June 30th, 1887, at 7 per cent. per annum, is also £24,743; and then there is for payment on account of this cumulative dividend on the A shares for the year to June 30th, 1888, at the rate of 4 per cent., £14,139. Those three sums amount to £63,626, which is the amount we propose to distribute out of the £74,810, and the balance we propose to carry to the reserve fund. That, of course, requires your confirmation, and we shall submit to you a resolution authorising that application of the balance, if you approve it. With regard to the statements in the report, the Directors are glad to say that the electrical fittings business is prospering. The amount received as royalty from those who hold licences for manufacturing holders and sockets for incandescent lamps is satisfactory, and is likely to increase year by year. I have told you in other words the same story as to why we entered on the manufacture of these fittings, &c. This is a growing asset and one giving us great advantage, being protected, as it is, for a good many years. I now come to paragraph 5, which in very brief words records what in the earlier days of the Company would have been a positive calamity to us; and even in these days, when we have got this thing upon something like a sound basis, is a very great loss to us—I refer to the death, the very sudden death—it was almost awful in its suddenness—of Mr. Leyland. If I were to say what I feel personally about this I should say a good deal. If I attempted to enlarge upon how great his services were to this Company, how much our issue from tribulation turned upon his judgment and courage, I should also have to say a great deal; but it has been said so often that I am sure it must be familiar to the proprietors. I will, therefore, not enlarge upon it except to express our regret and the sense of loss we feel at the death of so able a colleague. I am quite sure that the shareholders who have been accustomed to hear and see him, and know what he was, will share very deeply with us in that feeling. His death created a vacancy, which had to be filled, and we thought, looking to the position which Major Flood Page had held in the concern for a good many years, that, like some others among us, he was not getting younger, and that the time had come when he might very properly be relieved of some of the harassing duties of a business which is made up of innumerable details, constantly changing in its elements, growing in its scattered relations all over the kingdom, and with a large factory involving enormous manipulation to support. We therefore thought we might put him on the Board in place of Mr. Leyland. I need not say that either the chairman or the deputy-chairman of a public company has rather more work cast upon him in the way of attendance than the Directors generally. Boards are, of course, composed of several gentlemen who meet at stated intervals, and frequently if need be, but very few Boards are so constituted that the gentlemen composing them can go to the business very often, or, if necessary, every day of the week. Therefore the chairman and the deputy-chairman have to take upon themselves not only the ordinary duties of Directors, but also the general business, and they have to devote a good many hours of every week, and sometimes every day, to watching the details of a business of this sort. I hope you will confirm the judgment of the step which we took in this matter. The Earl of Lichfield and Mr. Ernest Villiers retire by rotation from the Board, and being eligible they offer themselves for re-election; and the auditors also retire. That really is pretty nearly all that I have to say on the report. The balance-sheet, I think, you can probably judge

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of for yourselves. As regards the capital account, things are left where they were. It shows the different items that go to make up the capital The capital is about £353,000, and then you have 23,564 B shares, representing £117,000. They are the shareholders who get nothing until you have had your 7 per cent. cumulative. Then there are sundry credit balances which we owe, amounting to £16,493: but that may set against debtors on the other side, amounting to £30,809. We are, therefore, all right there; and our debtors are all good. On the credit side of the balance-sheet you see where the money of the shareholders has gone to. The sum of £236,000 represents the cost of the patents, goodwill, preliminary outlay, loss on working, &c. In the Manchester Edison-Swan Company we have £12,000 upon which no dividend is paid to us at present. I do not know whether it is within the bounds of possibility that that Company may so develop in time as to be able to pay a dividend on their Deferred shares. If they do, that asset will be worth something; if not it will not be worth much. In freehold property we have £39,453, and plant and stock stand for £67,000. With respect to our freehold property we have bought a considerable acreage of land at Ponder's End, with enormous buildings upon it, for the purposes of a factory; and that land and property was sold to us at a time of great depression and under circumstances which made the bargain for us exceedingly advantageous. The plant and stock represent the two items I have mentioned of lamps, &c., in hand, and the plant and machinery which we, out of capital, paid to make that factory a going concern. I suppose I may sum up this matter by saying that if we had to start afresh and find land in a position as advantageous, and had to put on it buildings and plant as efficient as we have there now, it would cost a great deal more than these two sums represent, from which I draw the inference that as long as this business can be proceeded with, we have a factory and land bought very economically, and as its capacity for production is very large, for a good many years as a going concern it will be of great value to the Company, and may be regarded as a very sound asset. We have investments in Consols at cost, figuring for £20,000; and cash at bankers and in hand amounting to £30,719. That is the state of the accounts, and, as I said before, it is very simple. Subject to being ready to answer any questions, I will now propose—

"*That the report and accounts for the year ending June 30, 1892, be received and adopted.*"

The DEPUTY CHAIRMAN (Major Samuel Flood Page) seconded the motion.

Mr. LORRAIN said that with reference to the question of the expiration of the patents, and the competition which that event might produce, if there were 100 competitors they would simply advertise this Company's goods. One argument was that foreign lamps would be introduced, made where labour was very cheap. Upon that point he would like to ask Mr. Forbes whether his (the speaker's) view was correct—that whatever occurred in that way their Company would have no loss; for, as he understood, the Swan Company had factories where labour was very cheap. Was he right that the Edison and Swan Company and the Swan United Company worked so hand in hand that when the time in question came, they would be able to gain by one hand what they lost by the other?

The CHAIRMAN: This is an exceedingly interesting question, and, as the honourable proprietor observed, does bear so very much upon the figures that I can only congratulate my colleagues and myself upon having stated so clearly to you what has guided us very much in our policy over a good many years. As you know, we went through some difficulties and troubles. We had to eliminate from the business the errors of its youth—the installations which did not pay, the contracts to light, upon which there was a severe loss. We had, in fact, the courage to pull ourselves together, and cut the first loss, and to confine ourselves to the comparative humble *rôle* of making lamps; and for a great many years we have avoided the risks of installations, leaving that work to the electric lighting companies, and confining ourselves to the lamps. As an illustration of having at one's elbow a man of courage—in fact, two men—I may mention that when our litigation was carried to a decision in the Law Courts, we found our patents protected; but we found a strong disposition on the part of very high legal authorities to advise that, instead of retaining the manufacture exclusively in our own hands, we should give it out to licensees. Now, although we had the highest respect for the legal abilities of the distinguished men who gave that advice, we made up our minds that we would not follow it. We thought that if we retained the exclusive control of the manufacture, we should do two things—probably attract to ourselves such inventions as there might be during the protected period, and that we should certainly have the opportunity of insisting on the most efficient production of the lamps. We should thus build up in the market a reputation for the best article, and establish for ourselves a *clientèle*, so that when we emerged from the protected period into the competition we should have the advantages of a good name, a good article, and a large connection. I believe that was very wise, and I believe it will tell, because I quite agree with Mr. Lorrain that patents have their advantages, but they also have their disadvantages. I wonder if I can go so far as to suppose it possible that if there had been no patent in these lamps, the sale of them might have been rather larger. I think that rather likely under free competition, especially as the circumstance, happily for us, of what I may call the expansion of electric lighting has gone on through the means of the electric light companies, who are popularising the lamp. I think, however, we shall find that, although we have had certain advantages of price and exclusive dealings during the term of the patent, when we are in the open market there will be such a gradual developing to such a large expansion of this business that the profit will really remain in the hands of those who have the best trade mark and the best hold upon the business. Now, that is what we felt, and that is what Mr. Lorrain has put before you. I do not, therefore, think that we need suppose that a large return upon the capital of this Company is going to be knocked suddenly out of existence.

The resolution was then submitted to the meeting and carried unanimously.

The CHAIRMAN afterwards proposed the following resolution:—

"*That a dividend be, and is hereby, declared on the "A" shares of the Company of* 5*s.* 8½*d. per share on the* 89,261 *ordinary shares,* £3 *paid; of* 9*s.* 6½*d. per share on the* 5,000 £5 *fully-paid shares allotted to the Edison Electric Light Company (Limited); and of* 8*s.* 10½*d. per share on the* 12,139 £5 *fully-paid shares allotted to the Swan United Electric Light Company (Limited), free of income tax, being, with the interim dividend paid on February* 22, 1892, 7 *per cent. in respect of the year ending June* 30, 1892; 7 *per cent. in payment of arrears of cumulative preferential dividend for the year ending June* 30, 1887; *and of* 4 *per cent. in respect of the year ending June* 30, 1888; *all to be distributed in accordance with the provisions of clause* 87 *of the Articles of Association, and that the balance be carried to reserve.*"

The DEPUTY CHAIRMAN seconded the motion, which was carried unanimously.

Resolutions were afterwards passed, re-electing the retiring Directors (the Earl of Lichfield and Mr. Ernest Villiers), and the auditors, Messrs. Welton, Jones, and Company.

A vote of thanks to the Chairman and Directors was unanimously agreed to, which was acknowledged; and the proceedings terminated.

Manchester Edison-Swan Company (Limited).

The annual meeting of this Company was held on Monday, at the Victoria Hotel, Manchester; Mr. V. K. Armitage, Chairman of the Company, presiding.

The Directors' annual report stated that the net profits for the year, including last year's balance, amounted to £2,826. 1s. 10d. Out of this it was proposed to pay a dividend at the rate of 5 per cent. per annum, which will absorb £1,000, to carry £1,000 to reserve fund, and to carry forward a balance of £826. 1s. 10d.

On the motion of the CHAIRMAN, seconded by Mr. W. P. JAMES FAWCUS, the report was adopted, and the dividend recommended therein was declared payable. Mr. Armitage was re-elected a Director of the Company, and votes of thanks were accorded to the Directors for their services.

Electrical Power Storage Company (Limited).

The third ordinary general meeting of this Company was held at 4, Great Winchester-street, E.C., on Wednesday, the 20th inst. Mr. John Irving Courtenay presided.

Mr. J. W. BARNARD (the Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: Gentlemen, I intend to make but few observations to-day. The Directors' report and balance sheet I know you will regard as very satisfactory. The dividend of 6 per cent. has been earned by our secondary battery manufacturing business at Millwall during the twelve months that have elapsed since we took it over from the Electric Construction Corporation, and it is for that period; you will be pleased to learn that a most gratifying increase of business has taken place in that time. The financial position of the Company is a strong one—a good balance of cash, nearly £10,000, at our bankers—and current accounts due to us upwards of £11,000, as against about half that sum owing by the Company, and there is still a substantial amount of uncalled capital. I must here heartily thank our manager (Mr. Frank King) and our staff for the skill and energy he and they have displayed during the past year. The E.P.S. batteries continue to hold the field against all comers. The award of the only gold medal given solely for secondary batteries at the Electrical Exhibition at the Crystal Palace is a fresh proof of the unrivalled excellence of the E.P.S. batteries. Numerous secondary batteries continue to be introduced so far as Blue Books, specifications, laboratory experiments, and newspaper paragraphs can introduce them; but they all die shortly after their birth, and in a commercial point of view are heard of no more. During the last ten years, scarcely a year has passed without some alleged improvement having been trumpeted forth as about to revolutionise the storage battery business; but the supporters of these inventions are now sadder, if not wiser, men.

Because we make the best battery in the market we do not therefore say "rest and be thankful:" on the contrary, Mr. King is always on the *qui vive* to improve, if possible, the E.P.S. manufactures, and to keep the foremost position, of which you have tangible proof in the largely increased sales of the E.P.S. batteries for lighting and other purposes.

For traction purposes especially we may look for an increased demand for the E.P.S. batteries, and close attention is being given to this particular branch of the business. I think there should now be a further improvement and further development in our foreign business, which has been hindered by competitors in several directions; but the Courts in various countries are, I think, at last arriving at conclusions favourable to the interests of those who are supporting the patents, as for instance the decision of the Imperial Court of Appeal at Leipsic, by which the validity of the Faure patent in Germany is finally decided; and again, the decision in favour of the Swan patent recently given in the United States. In this connection I may add that the Directors are also keeping a watchful eye upon what is being done by others in the storage battery business in this country, and it may yet be their duty to take steps for the more effectual protection of our British business. I do not propose to detain you longer, and will conclude by stating

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that I consider the prospects of the Company are excellent. I beg to move the following resolution :—

"*That the Directors' report and statement of accounts to May 31, 1892, be and are hereby approved and adopted, and that a dividend of 6 per cent. on the paid-up capital be declared, payable on the 21st inst.*"

I will ask Sir Daniel Cooper to second the resolution.

Sir DANIEL COOPER, Bart., G.C.M.G.: Gentlemen, it is not necessary for me to extend at any length the observations of your Chairman, Mr. Courtenay, except upon one point, which I think is a very clear one. It is well known to you that the old E.P.S. Company was taken over by the E.C.C. Company, and the business of the Company after it went into their hands decreased, but within twelve months of the time of taking it over we have regained all that was lost, and we hope to do a larger business in the present year than we have done during last year. So far as we know, and can estimate, I may assure you that although our patents—the time for our patents —may shortly expire; yet under the system of making secondary batteries pursued at the present time, it is almost impossible—as far as I can see—at all events, at the present time, for anyone to make batteries of any better quality than we have been making and shall continue to make, and which we have sold from time to time. I have no doubt that the business will be maintained if we continue to manufacture goods of the quality that we have done, and I feel quite confident myself that this Company will continue to be very successful. I have, gentlemen, great confidence that the business will prosper, and that we shall earn for you a very good dividend.

The CHAIRMAN then invited discussion; and no questions being asked, he said: Since there is no opposition to it I will put the resolution. Those in favour—on the contrary. It is carried unanimously. Now, gentlemen, the second resolution which I have to propose is one for the re-election of two of our Directors, Mr. Frederick Green and Mr. James Pender. Mr. Frederick Green has been, as you all know, a Director of the Electrical Power Storage Company from the very beginning, but Mr. James Pender has only joined us since what I may call the new Electrical Power Storage Company came into existence. I have much pleasure in proposing the re-election of these two gentlemen. The resolution is as follows :—

"*That the retiring Directors, Mr. Frederick Green and Mr. James Pender, be and are hereby re-elected Directors of the Company.*"

Sir HENRY MANCE, C.I.E., seconded the motion, and the resolution was unanimously carried.

The CHAIRMAN: The next resolution must be moved by the shareholders—it is the re-election of auditors.

Sir HENRY MANCE: I shall have much pleasure in proposing—

"*That the auditors, Messrs. Broads, Paterson, and Co., be voted a fee of £120 for their audit of the accounts to May 31, 1892, and that they be and are hereby re-elected auditors of the Company for the ensuing year.*"

Mr. W. SAMSON seconded the motion, and the resolution was unanimously carried.

The CHAIRMAN: Thank you, gentlemen, for your attendance. This is all the business that we have got to do to-day, and I hope that upon future occasions we shall have an equally satisfactory and short meeting, and that the result will be equally good.

On the motion of Sir HENRY MANCE, seconded by Mr. GREEN, a vote of thanks was accorded to the Chairman for presiding; and the meeting separated.

Sheffield Telephone Exchange and Electric Light Company (Limited).

The third ordinary general meeting of this Company was held at the Cutlers' Hall, Sheffield, on Monday. The report of the Directors was adopted. The sum of £795. 6s. 11d. was added to the reserve fund, and a dividend at the rate of 5 per cent. per annum was declared upon the ordinary shares.

At an extraordinary meeting subsequently held it was decided to reconstruct the Company, under the title of "The Sheffield Electric Light and Power Company (Limited)," having for its object the exploitation and development of the Parliamentary powers recently granted to the Company for the electric lighting of a compulsory area in the centre of the town, and also the application of electricity to commercial requirements generally, respecting which there is a largely-increasing demand. The Directors propose to pay off all the preferential shareholders with interest to date, and to reduce, to some extent, the capital of the Company, this course being rendered possible by the sale of the Company's telephone exchange.

Direct United States Cable Company (Limited).

The following is the report of the Directors, to be presented at the ordinary general meeting of the Company, to be held at Winchester House, Old Broad street, E.C., on Friday next, the 29th inst., at 2 p.m.:—

The revenue for the half-year ended June 30, 1892, after deducting outpayments, amounted to £39,014. 14s. 1d., against £37,352. 19s. 5d. for the corresponding period of 1891, being a difference of £1,661. 14s. 8d. in favour of the half-year under review. The working and other expenses for the same period, including income-tax, but exclusive of cost of repairs of cables, amounted to £19,018. 11s. 3d., leaving a balance of £19,996. 2s. 10d. as the net profit of the half-year, making, with £4,982. 15s. 3d. brought forward from the previous half-year, a total of £24,978. 18s. 1d. For the corresponding period of 1891, the working expenses and other payments amounted to £18,112. 19s. 8d.

Three quarterly interim dividends of 3s. 6d. each per share, amounting to £31,872. 15s., have been declared and paid during the financial year, and a final payment of 3s. 6d. per share is now proposed, making, with the three interim dividends, 3½ per cent for the year, being a total distribution of £42,497. The balance of £3,730. 8s. 1d. on the revenue account it is proposed to carry forward.

During the period under review, repairs have had to be made in both sections of the Company's cables at a cost of £9,385. 6s. 2d., which has been debited to the reserve fund account as heretofore, the balance of which now stands at £254,716. 13s. 10d.

The Directors have to report with extreme regret the deaths of their esteemed colleagues, Mr. William Ford on May 14th, and Admiral R. C. Mayne on May 29th last. The vacancy on the Board occasioned by Mr. Ford's decease has been filled up by the election of Mr. James Pender. It is not intended at present to fill up the second vacancy. Pursuant to the provisions of the Articles of Association, two of the Directors, viz. :—C. J. Günther, Esq., and Admiral of the Fleet the Hon. Sir Henry Keppel, G.C.B, D.C.L., retire by rotation, and, being eligible, offer themselves for re-election. Mr. John G. Griffiths, F.C.A., and Mr. John Sawyer, F.C.A., the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

Anglo-American Telegraph Company (Limited).

The following report has been issued by the Directors of this Company, and will be presented at the meeting of the proprietors, to be held on Friday next, the 29th inst., at Winchester House, E.C., at 2 o'clock :—

The total receipts from January 1st to June 30, 1892, including the balance of £864. 6s. brought forward from the last account, amounted to £147,818. 19s. 9d. This sum, however, is subject to revision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending before the Court of Appeal in Paris.

The traffic receipts show an increase of £10,035 as compared with the corresponding period of last year.

The total expenses of the half-year, including the repair of cables, &c., as shown by the revenue account, amounted to £59,364. 1s. 10d.

One quarterly interim dividend of 12s. 6d. per cent. on the ordinary stock, and of £1. 5s. Cd. per cent. on the preferred stock, was paid on April 30, 1892, absorbing £43,750, and a second quarterly dividend at the same rates will be paid on July 30, 1892, leaving a balance of £954. 17s. 11d. to be carried forward to the next account.

The Company's repairing steamship "Minia" has been engaged during the past half-year in the repair and partial renewal of the 1869 cable between Brest and St. Pierre, Miquelon, at a distance of 270 miles from Brest, and also in the repair and diversion of the North and South Placentia cables, between Placentia and St. Pierre.

The Company's cables and the land lines in connection therewith are in good working order, with the exception of the Brest-St. Pierre cable, which was again broken on the 14th inst. The disastrous fire which occurred at St. John's, Newfoundland, on the 9th inst., destroyed the telegraph station and the local wires in the immediate vicinity; the instruments, however, were saved and transferred to temporary offices, from which they are now being worked. The telephone system belonging to the Company was also partially destroyed. This accident does not in any way affect the through communication on the Company's main Atlantic cables.

Little or no progress has been made since the last report in the lawsuit so long pending between this Company and the Paris and New York Telegraph Company.

The Directors greatly regret to announce the death of their highly valued colleague Mr. Cyrus W. Field, which occurred on the 12th instant.

Mr. Field was amongst the first believers in the possibility of connecting Europe with America by submarine cable, and by his untiring energy and ceaseless advocacy on both sides of the Atlantic largely contributed to the successful establishment of the first Atlantic telegraph cables.

Globe Telegraph and Trust Company (Limited).

The following is the report of the Directors of this Company, to be presented to the nineteenth ordinary general meeting to be held at Winchester House, E.C., on Tuesday, the 26th inst., at one o'clock :—

The net revenue for the year ending July 18th inst., after deduction of expenses, amounts to £192,243. 16s. 6d., and makes, with the balance of £1,876. 15s. 9d. brought forward, a total of £194,120, 12s. 3d. From this amount there has been distributed the sum of £133,059. 8s. 3d. in interim dividends, leaving an available balance of £61,061. 4s. The Directors recommend the payment of a final dividend for the year of 3s. per share on the preference shares, and of 3s. 9d. per share on the ordinary shares, making, with the former distributions, a total dividend for the year of 6 per cent., less income tax, upon the preference, and 4½ per cent. net (against 5½ per cent. for the preceding year) upon the ordinary shares, and carrying forward a balance of £938. 4s. 1d.

The Imperial German Government have, in virtue of their agreement entered into with the German-Norwegian Telegraph Company, taken over that Company's undertaking, and have paid off its capital. On reference to last year's report, it will be seen that 95 per cent. of this Company's investment in the German-Norwegian Company had been received in that year, the balance received in February of the present year has been invested in the West Coast of America Telegraph Company's Shares.

The Directors regret to report the death of their much-valued colleague, Mr. William Ford. Lord Sackville A. Cecil has been elected to fill the vacancy on the Board of Directors. The Directors have also to record, with much regret, the decease of Mr. W. Payton, who occupied the post of Secretary to this Company for many years.

In conformity with the Articles of Association, Sir John Pender, K.C.M.G., M.P., and Sir James Anderson, two of the Directors, retire,

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and offer themselves for re-election. The auditors, Mr. John George Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and Mr. William Griffith, B.A., Barrister-at-Law, also retire at the meeting, and offer themselves for re-election.

Telephone Company of Austria (Limited).

The following is the Directors' report, to be presented at the ninth ordinary general meeting, to be held at 53, New Broad-street, E.C., on Thursday next, the 28th inst., at 3:30 p.m. :—

There has been expended on capital account during the year ending March 31, 1892, a further sum of £5,602. 9s. 2d. The gross receipts in Austria were £20,759. 14s. 5d. After providing for all expenses. including £4,655. 8s. for debenture interest and dividend on preference shares, and £3,177. 17s. 2d. for royalties and taxes to the Austrian Government, the profit on the year is £3.825, 1s. 10d., which, with the £4,485. 18s. 9d. balance from last year, gives a total of £8,311. 0s. 7d. to the credit of profit and loss account, which amount it is proposed to carry forward.

As foreshadowed in the report of last year, an agreement has been come to between the Company and the Austrian Government, for the latter to take over on December 31st next the whole of the Company's exchanges at a purchase price of 1,000,000fl., plus all sums spent on account of capital since May 1, 1891, payment to be made in cash within the first fortnight in 1893. There are other minor details to complete the agreement, which will have every attention on the part of the Board. The effect of this agreement will be the holding of a general meeting early next year to place the Company in voluntary liquidation, and to authorise the distri bution of the capital.

The Directors have again to report a continued increase in the number of subscribers to the Company's exchanges, as shown by the following table :—

	No. of subscribers.	Increase over previous 12 months.	Rental.	Increase over previous 12 months.
March 31, 1891 ..	3,023	 371	..... 239,000fl.	..... 28,000fl.
March 31, 1892...	*3,332	 309	..... 262,000fl.	..... 24,000fl.

* Exclusive of 256 "extension" telephones, which give an additional annual rental of 9,025fl.

The calls of subscribers now average 108,675 per week, as against 97,000 last year.

The Directors deeply regret to have to record the death of Dr. Eugen Weissel in December last, and desire to give expression to their deep sense of the invaluable services he rendered to the Company during the whole period of his connection with it as one of its representatives in Austria, and especially during the late negotiations with the Austrian Government for the purchase of the business. Dr. Joseph Griez de Ronse has been appointed to fill the vacancy on the Local Board in Vienna caused by the death of Dr. Weissel.

The thanks of the shareholders are again due to Mr. Krause for the very satisfactory manner in which he continues to perform his duties as General Manager.

Mr. C. L. W. FitzGerald retires by rotation from the Board, but being eligible offers himself for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also retire, but being eligible offer themselves for re-election.

Crompton and Co. (Limited).

The following is the report of the Directors, to be presented at the annual general meeting to be held at the City Terminus Hotel, Cannon-street, E.C., on Friday next, the 29th inst., at 2:30 o'clock p.m. :—

The Directors have pleasure in submitting to the shareholders the fourth annual statement of accounts and balance-sheet made up to the 31st March last, to report that the business of the Company continues satisfactory, and that the reorganisation and additions to the Chelmsford works have proved a great advantage in increasing the output and reducing the cost of manufacture.

In order the more effectually to separate the accounts for the electric lighting of Chelmsford from the manufacturing and other accounts of the business, the Directors have caused to be registered the Chelmsford Electric Lighting Company (Limited), to which Company the installation outside the arc works has been transferred. The shares in the new Company will of course be chiefly held by this Company. The private lighting at Chelmsford is increasing very satisfactorily, and in a short time it is anticipated the new Company will be working at a profit.

The whole of the preference shares offered to the members in November last having been subscribed, the Directors now propose to issue the balance of 4,781 shares at a premium of ten shillings per share, and the members are invited to send their applications for the same to the secretary upon the form accompanying the report. This will complete the authorised issue of shares, and will provide the working capital necessary for the business as stated at the meeting last year. The premiums will be placed to reserve.

The net profits for the year amount to £15,068. 16s. 11d., and after providing for the debenture interest and other payments set out in the revenue accounts, and deducting the interim dividends already paid on both the preference and ordinary shares, there remains, with the £127. 7s. 5d. brought forward from last year, a balance available for dividend of £7,347. 7s. 4d. The Directors propose, after setting aside £750 as a provision for doubtful debts and contingencies, to declare a dividend of 3s. 6d. per share, making 7 per cent. per annum upon the preference shares, and 4s. 6d. per share, making with the interim dividend, a total of 7 per cent. per annum upon the ordinary shares, to place a further £1,000 to the reserve fund, and to carry the balance forward.

In accordance with the Articles of Association, Mr. C. F. Tufnell retires from the Board of Directors by rotation, but offers himself for re-election. The auditors, Messrs. J. H. Duncan and Co., also offer themselves for re-election.

Compagnie Française du Télégraphe de Paris à New York.

We gave in last week's *Electrician* a brief report of the proceedings at the annual meeting in Paris of this Company, held on the 12th inst. The following is an abstract of the Directors' report submitted to the meeting :—

The net receipts during 1891 amounted to fr. 1,256,930.79, and the total expenses to fr. 1,210,877.47, leaving a balance of fr. 46,053.32 ; the net receipts and the expenses showing increases as compared with 1890 of fr. 88,488.23 and fr. 131,147.74 respectively. The expenses had been sensibly diminishing during the present year, while the receipts up to May 15th showed an increase of fr. 116,000 compared with 1891.

Two interruptions had occurred during last year on the St. Pierre-Canso section of cable, and one each on the Brest-St. Pierre and the St. Pierre-Cape Cod sections, all of which had been repaired by the ss. "Mackay-Bennett."

Negotiations had been in progress with the United States Government for permission to land the Company's proposed Antilles cable in North America, and the Directors had every hope of success ; in the event of non-success the cable could be landed at St. Pierre, where no authorisation would be necessary, the island being a French possession.

The Company's appeal against the decision of the Conseil d'État in favour of the Anglo-American Telegraph Company (Limited) had not yet been reached in the Cour d'Appel, but the Directors had every hope of a favourable result whenever the case came on.

The Directors devoted considerable space in their report to a review of the circumstances leading to the attempt by the Americans to obtain command of the administration of the Compagnie française to the detriment of French interests. It was well known, the Directors said, that Mr. Mackay, the President of the Commercial Cable Company, had since 1886 acquired twenty thousand shares in the Compagnie Française, which he had made over to the Commercial Cable Company. Between the two companies an agreement was in existence in case of a breakage of either of their cables, and for six years they had been on the best terms with each other—a state of affairs suddenly terminated by the Commercial Cable Company. The Compagnie Française had had for four years a project for laying a cable between the Antilles and North America, and had been in negotiation for that purpose with the French Government and with the Société française des Télégraphes sousmarins. The total cost of the cable between New York and Puerto Plata (St. Domingo) would be seven million francs, which sum would be raised by the issue of 14,000 Five per Cent. Debentures, repayable in twenty-five years. A net annual income was estimated of fr.650,000, without taking into account the receipts from the Brazilian traffic, which it was thought would be considerable. The Commercial Company approved of the negotiations which were going on, and Mr. Mackay had interested himself in assisting to obtain for the Compagnie Française the necessary permission to land the cable at New York. There were great difficulties in the way of obtaining this permission, but in the opinion of eminent American lawyers they were not insurmountable ; and the Directors were continuing their negotiations, when in June, 1891, Mr. Mackay sent three representatives of the Commercial Cable Company (Mr. Mackay, jun., Mr. G. Ward, and Mr. Hosmer) to intimate that the latter Company did not wish the Compagnie Française to go any further with their Antilles cable project, as the Commercial Company and the Canadian Pacific Railway Company had purchased the Halifax-Bermudas Cable and would themselves make the proposed connection. The Directors absolutely declined to abandon their proposed cable, and from that moment an attempt was commenced to oust them and replace them by others more docile to Mr. Mackay's orders. The Directors appealed to the shareholders as to whether they had not done right in resisting Mr. Mackay's demands.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

ALBRIGHT AND WILSON (LIMITED).—This Company was registered on the 15th inst., with a capital of £400,000, divided into 1,000 preference and 3,000 ordinary shares of £100 each, to acquire and take over as a going concern the business and undertaking of Albright and Wilson, manufacturing chemists, at Oldbury, Worcestershire. The Directors include Mr. John F. Albright, of Mansion House-buildings, London, E.C., and Mr. Henry L. Wilson, of Birmingham.

CENTRAL IRONWORKS COMPANY (LIMITED).—This Company was registered on the 15th inst., with a capital of £3,000, in £1 shares, to carry on the business of iron and steel merchants, mechanical and electrical engineers, &c., at the Central Ironworks, Rockingham-lane, Sheffield.

CENTRAL RAIL TRACTION COMPANY (LIMITED).—This Company was registered on the 13th inst., with a capital of £10,000, in £10 shares, to

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acquire certain Letters Patent granted to Frederick Purdon, Henry E. Walters, Basil Mott, and Patrick O'Donnell, numbered 13,351 and 13,352, for an invention for "Improvements in the Permanent Way of Railways," and for an invention for "Improvements in connection with Rolling Stock for Railways," and other rights and privileges belonging to or in connection with the said Letters Patent, and to carry on the business of electrical and mechanical engineers, machine and engineering tool makers, metallurgists, manufacturing chemists, &c.

ELECTRICAL COMPANY (LIMITED).—This Company was registered on the 13th inst., with a capital of £15,000, in £5 shares. The objects are to acquire and take over the business, assets, and liabilities of Keys Electrical Company (Limited), with a view thereto to enter into and carry into effect an agreement with the said Company and its liquidator, mentioned in Clause 3 of the Articles; to carry on the business of electrical engineers, mechanical engineers, manufacturers of and wholesale and retail dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity, and contractors for the supply of electricity for all purposes. The subscribers are:—

	Shares.
Franz Deutsch, Warnford-court, E.C.	1
Frederick T. Eggers, 24, Upper Bedford-place, W.C.	1
Victor Melcher, 166, Shaftesbury-avenue, W.C.	1
Ernst A. Bartels, 10, Blenheim-gardens, Willesden Green, N.W.	1
Alfred A. Rothschild, 37, Cleveland-square	1
Cæsar Schlesinger, 11, Portland-place, W.	1
Oscar Hertz, 56, Belsize Park-gardens, N.W.	1

The number of Directors is not to be less than two nor more than five, the first being Franz Deutsch and Felix Deutsch.

J. W. NEWTON AND CO. (LIMITED).—This Company has been registered with a capital of £10,000, in £1 shares, to acquire the undertaking of an india-rubber manufacturer, hitherto carried on by J. W. Newton and Co., at 79, Mark-lane, E.C.

JAMES SIMPSON AND CO. (LIMITED).—This Company has been registered with a capital of £250,000, in £10 shares. Object, to acquire the undertaking, property, and assets of James Simpson and Co., Limited (registered December 19, 1885); and, generally, to carry on, at the Engine Works, Grosvenor-road, Pimlico, and elsewhere, the business of engineers, machine and engineers' tool makers, boiler-makers, iron and brass founders, millwrights and metal founders.

JOSEPH SYKES BROS. (LIMITED).—This Company was registered on the 16th inst., with a capital of £100,000, in £50 shares, to acquire and carry on the business of wire manufacturers, mechanical and electrical engineers, machine and engineering tool makers, &c., carried on by the firm of Joseph Sykes Brothers, at Acre Mills, Lindley, Huddersfield.

LIRONI AND BOWMAN (LIMITED).—This Company was registered on July 13, 1892, with a capital of £2,500, in £1 shares. The objects are to acquire and take over as a going concern the business heretofore conducted by Messrs. Vittorio G. Lironi and John J. Bowman, at the Bow Electric Works, Arnold-street, Bow, E.; to enter into an agreement with V. G. Lironi and J. J. Bowman, and also with Thomas W. and Alfred J. Hollington, and to carry on the business of electrical engineers, electricians, mechanical engineers, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all apparatus and things required or capable of being used in connection with the generation, supply, accumulation, and utilisation of electricity. The first Directors are A. J. Hollington, T. W. Hollington, V. G. Lironi and J. J. Bowman.

THEATRE ELECTRICAL AND SPECIALITIES PRODUCTION COMPANY (LIMITED).—This Company was registered on the 12th inst., with a capital of £5,000, in £1 shares. The objects are to take over the business of Messrs. Gritton, Madgen, and Heald, of 28A, Leicester-square, and to carry on the business of theatrical and music-hall proprietors and managers, gas and electrical engineers and contractors, mechanical engineers, &c.

UNIVERSAL ARC LAMP SYNDICATE (LIMITED).—This Company was registered on the 16th inst., with a capital of £3,000, in £1 shares. The objects are to acquire, develop, and turn to account a certain invention of improvements in electric arc lamps, for which a patent was applied on April 13, 1892, and which is described in the provisional specification No. 7,095 of 1892; to carry on the business of an electric light and power company in all its branches, and in particular to generate, accumulate, distribute, and supply electricity, and to carry on the business of electricians, electrical and mechanical engineers, and manufacturers of and dealers in electric lamps and all apparatus and things required for, or capable of being used in connection with, the generation, accumulation, distribution, supply or employment of electricity. The subscribers (with one share each) are:—Charles H. Freedman, 66, Berners-street, W., electrical engineer; Arthur R. Carter, 4, Arthur-street, New Oxford-street, W.; Arthur H. Vesey, Cadogan-gardens, S.W., civil engineer; Frank Suter, 90, Lady Margaret-road, Kentish Town, N.W., electrical engineer; Harrington Wyman, 66, Berners-street, W., electrical engineer; James Yelloley, 15, Birdhurst-road, Wandsworth; Charles Wyman, 82, Leverton street, Kentish Town, N.W. The first Directors are Charles H. Freedman, Frank W. Suter, and Arthur R. Carter.

BRADFORD MUTUAL ELECTRIC LIGHTING COMPANY (LIMITED).—This Company, registered with a capital of £10,000, in £5 shares, to supply electric light, heat, and power to a detached block of buildings situate near Kirkgate, Ivygate, New Tyrrell-street, Hustlergate, Albion-court, and Queensgate, Bradford, Yorks, was dissolved by notice in the *London Gazette*, dated June 21, 1892.

ELECTRIC SEWAGE UTILISATION AND IMPROVEMENTS COMPANY (LIMITED).—This Company, registered in 1886, with a capital of half a million in £1 shares, to acquire, develop and turn to account certain patents and patent rights mentioned in an agreement dated October 13, 1886, made between the International Canalisation Company of Berlin, and others of the one part, and Arthur C. Woodington (for this Company) of the other part, was dissolved by notice in the *London Gazette*, dated June 21, 1892.

LEEDS AND LONDON ELECTRICAL ENGINEERING COMPANY (LIMITED).—The statutory return of this Company, made up to December 31, 1891, was filed on April 30, 1892. The nominal capital is £100,000, divided into 250 founders', 9,750 preference, and 10,000 ordinary shares of £5 each; seven shares have been taken up, but no calls have been made, the original signatories being the only shareholders.

NEW PORTABLE ELECTRIC LAMP AND POWER SYNDICATE COMPANY (LIMITED).—The following notice was filed on June 23, 1892:—"Sir: We beg to inform you that a meeting of the above-named Company was duly held on June 22, 1892, for the purpose of having an account laid before them showing the manner in which the winding up of the Company had been conducted, and the property of the Company disposed of, and the same was done accordingly. (Signed) J. H. Hays, B. Nicholson, liquidators." The Company was registered on February 2, 1887, with a capital of £9,000, in 45 shares of £200 each, to take over the business and assets of the Portable Electric Lamp and Power Syndicate Company (Limited).

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The annual return of the above-named Company, made up to July 11th (being the fourteenth day succeeding the first ordinary general meeting in 1892), was filed on the 14th. The Company was registered on December 29, 1877, with a capital of £300,000, in £10 shares. At the time of making up all the shares had been taken up, the full amount called and all calls (£300,000) paid.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—The Board of Directors have resolved to declare an interim dividend for the quarter ended June 30, 1892, of 12s. 6d. per cent. on the ordinary stock, and 25s. per cent. on the preferred stock, less income-tax, payable on July 30th to the stockholders registered on the books of the Company on the 11th July, 1892.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons on this Company's Five per Cent. Debentures (1884 issue), due the 31st instant, will be paid on and after the 30th at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, E.C. Coupons must be left at the banks three clear days for examination.

CASSEL GOLD EXTRACTING COMPANY (LIMITED).—In their report to March 31st last the Directors recommend a dividend of 10 per cent., and that the sum of £20,000 be set aside to form a reserve fund, leaving an undivided balance of £7,333.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 17th were £766, as against £689 for the corresponding period of last year, being an increase of £77. The total receipts for half-year amount to £2,262, against £2,100 in the corresponding period of 1891, being an increase of £162. A dividend at the rate of ½ per cent. per annum is recommended by the Directors of this Company on the ordinary shares for the past six months, after carrying forward the sum of £983.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED).—A further issue is made by this Company, this time for 20,500 Perpetual Ten per Cent. Guaranteed Preference Shares of £2 each, entitled in addition to 5 per cent. (making 15 per cent.) out of the surplus profits after the ordinary shares have received 15 per cent. The 10 per cent. interest is guaranteed for the first year by Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited). The present issue is payable 5s. per share on application, 10s. on allotment, 10s. on 1st September next, and 15s. on 1st October next. This issue completes the 60,000 shares authorised at a general meeting. The prospectus gives particulars of some very flattering reports from M. Secrétan, the general manager in France, and further states that since the Company has started regular manufacture good orders have been coming in, and complete satisfaction has been given to the customers. No mention is made of the objects of the present issue, applications for which close to-day (Friday) for town, and to-morrow (Saturday) for the country.

EUROPEAN GAS COMPANY (LIMITED).—At the ordinary general meeting held on Monday, the Chairman (Mr. H. McLauchlan Backler) said that they had during the past year been subject to sharp competition from the electric light, but there was evidence that those who used that light had found it more costly, and were now returning to the use of gas.

INDIA-RUBBER, GUTTA-PERCHA AND TELEGRAPH WORKS COMPANY (LIMITED).—An interim dividend of 10s. per share has been declared by the Directors.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).—A dividend has been declared at the rate of 6 per cent. per annum on the First Preference Shares in this Company for the half-year ended June 30th last.

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MANGANESE BRONZE AND BRASS COMPANY (LIMITED).—A further dividend of 12s. per share is proposed, making a total payment for the past year of 18s. per share.

MONTREAL WATER AND POWER COMPANY (LIMITED).—Amongst the new companies whose prospectuses have been issued during the current week is the Montreal Water and Power Company (Limited). In the prospectus the supply of power is estimated to be a substantial source of revenue to the Company in the future, and it is provided for in the prospectus that the installation of a plant for 500 H.P. shall be one of the first duties of the Company after allotment.

SUBMARINE CABLES TRUST.—Notice is given that on and after the 2nd August next the balance of £1. 17s. 6d. of the coupon due in April last will be paid by Messrs. Glyn, Mills, and Co., of 67, Lombard-street, between the hours of 10 a.m. and 2 p.m. The coupons should be left with bankers for examination four clear days before payment.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the fortnight ended July 15, 1892, amounted to £2,091, as compared with £1,973 in the corresponding period of last year, an increase of £18.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 15, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,559.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 13.	Price Wednesday, July 20.	Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending July 20. Highest.	Lowest.
			TELEGRAPHS			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	48 49	48 49	5 8 1	Jan., Apr., July, Oct.	48	..
£2,876,140	Stock	25/0	Do. Preferred	88 89	88 89	5 18 0	" "	88¾	88½
£2,876,140	Stock	5/0	Do. Deferred	10½ 11	10½ 11	..	" "	11	10½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 103	99 103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¼ 10¾	10¼ 10¾	6 10 3	Mar., June, Oct., Dec.	10¾	10⅞
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1⅓	Commercial Cable Capital Stock	155 160	155 160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	11⅞	11½
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3¼ 3⅜	3¼ 3⅜	4 16 9	April and October..	3⅜	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	8/6	Direct United States	11⅜ 11⅝	11½ 11⅝	5 19 2	Jan., Apr., July, Oct.	11⅝	..
400,000	10	2/6	Eastern	14⅞ 15¼	14⅞ 15¼	4 5 11	" "	15⅛	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16	15½ 16	3 15 0	" "	..	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	110¾	110
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	2/6	Eastern Extension xd	15 15½	14⅞ 15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101 104	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102 105	102 105	3 16 2	February & August	..	..
180,227	10	2/6	Globe Telegraph and Trust	10½ 10⅝	10½ 10⅝	5 1 2	Jan., Apr., July, Oct.	10⅝	10½
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	15⅝ 15⅝	3 18 1	" "	15⅝	15⅝
150,000	10	5/0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	18½	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	..	..
17,000	25	1⅜	Indo-European	40 42	40 42	5 19 1	May and November	40½	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October..	..	..
3,381	£100 Cert.	£1½	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	118	..
15,609	10	3/0	West African Telegraph	6 8	6 8	5 0 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	102½	..
30,000	10	2/0	West Coast of America	3½ 4½	3½ 4½	5 11 1	January and July ..	3½	..
£150,000	100	8%	Do. Debentures 8% 1902	101 105	101 105	7 12 5	June and December	..	..
88,321	10	6d.	West India and Panama	1¼ 1½	1¼ 1½	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10	9½ 10	6 0 0	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	8	..
64,242	15	6/0	Western and Brazilian	8¾ 9¼	8¾ 9¼	6 9 7	" "	9	8⅝
33,129	7½	1/6	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 7	" "	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾ 3¼	2¾ 3¼	..	" "	3⅛	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105 108	105 108	5 11 1	February & August	107	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105 108	105 108	5 11 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
£24,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
£20,000	£1	4¾d.	Oriental (11s. paid)	1/16 ⅛	1/16 ⅛	6 5 0	Yearly	..	..
438,984	5	2/6	National	4⅜ 5⅛	4⅜ 5⅛	5 17 1	June and December	5⅛	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13⅞ 14½	13⅞ 14½	4 4 3	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12¾ 13¼	13 13¼	4 8 11	" "	13¼	13¼
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	108 110	109 111	4 1 1	January and July ..	110¾	109
58,000	5	1/0	United River Plate	1½ 2½	1½ 2½	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	9¾ 10¼	9¾ 10¼	..	..	10⅛	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	2½ 3½	2½ 3½	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5½	5 5½	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 5¾	5½ 5¾	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16	3 7/16 3 9/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 7/16 5 9/16	5 7/16 5 9/16	..	March	..	..
111,000	5	..	London Electric Supply	¾ 1¼	¾ 1	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7	6⅞ 7¼	..	..	7	6⅞
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5	4 5	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	7⅞ 8¼	7¾ 8¼	..	..	7¾	7¾
7,900	£5	7%	Do. 7% Preference	8 8¾	7¾ 8¼	..	..	8¼	..
42,853	5	..	Westminster Electric Supply (fully paid)	6¼ 6¾	5¾ 6	..	..	6 7/16	5¾
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/9	Brush Electrical Engineering	2¾ 3¼	2¾ 3¼	..	..	2 13/16	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅞ 2⅞	2¾ 2⅞	5 1 1	..	2 15/16	2¾
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¾ 6	5¾ 6	5 16 8	January and July ..	..	..
12,139	5	17%	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	12/0	Electric Construction	4½ 5	4⅞ 5¼	..	..	5	4⅝
70,000	2	10/0	Elmore's Patent Copper Depositing	2 2¼	2 2¼	..	..	2⅛	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works xd	21 22	20½ 21½	5 16 3	February & August	21	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼ 5/16	¼ 5/16	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3 3⅛	3 3⅛	11 0 0	May and November	3⅛	3⅛
37,350	12	12/0	Telegraph Construction and Maintenance xd	45 47	44 46	5 4 6	March and July	45½	44⅛
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅛ ⅜	⅛ ⅜	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½ 3	2½ 3	..	..	—	—
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
50,000	£10	—	City and South London Railway	2½ 2¾	2½ 3½	—	—	..	..

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NOTES.

The number of Electrical Papers down for reading at the forthcoming meeting of the British Association at Edinburgh promises to be above the average. Thus in Section A, of which Prof. Arthur Schuster is President, Prof. Oliver Lodge will read a Paper on the "Influence of Magnetisation on the Velocity of Light," and Mr. Preece will have something to say on "Inductance." Profs. C. G. Knott and A. Schuster are respectively announced to read Papers on "The Volume Effects of Magnetisation" and "Primary and Secondary Cells in which the Electrolyte is a Gas." "A Contribution to the Theory of the Perfect Influence Machine" will be made by Mr. J. Gray; and Messrs. E. H. Barton and W. Williams will deal with "The Temperature Variation of the Magnetic Permeability of Magnetite." Prof. H. E. J. G. du Bois, of Berlin, has two Papers, one on "Leaky Magnetic Circuits," and the other on "A Magnetic Balance and its Practical Use." But the *bonne-bouche* of the meeting, we venture to prophesy, will be Prof. Ewing's magnetic curve-tracer, an instrument to which he has devoted much time and labour.

In Section G, of which Prof. W. C. Unwin is President, Mr. Preece has a Paper on "Secondary Batteries in use at the Central Telegraph Office," and Mr. Kapp has one on "Power Transmission by simple Alternating Currents." "Coal-cutting by Electric Power" will form the subject of a communication by Mr. Ll. B. Atkinson, and Mr. E. H. Woods will describe "A New Electrical Locomotive." Papers will also probably be read on telephony in the United Kingdom, and "The Human Body as a Conductor of Electricity."

The profuse promises and small performances which have characterised the revivified New Telephone Company since its new birth lent colour to the suggestion of the enemy that the whole thing was a gigantic piece of *blague*, a mere device for forcing the hand of the National Company. A perusal of our City Notes will show that such was, in fact, the case. The deliverer of the telephone renter has joined hands with the so-called oppressor, who subscribes one-third of the New Company's capital, and sends four "National" Directors to assist the deliberations of its Board.

The mean radius of supply of an electric lighting company is no such easy matter to determine, as our correspondent Mr. Cowan seems to think. We have already looked into this question; and among the statistical tables, which it is our custom to publish in our new year's number, we gave last January the gross and net area of the London companies' districts, and the plant capacity in lamps per square mile. We published on January 15th a map showing the streets in which electric mains were laid up to the end of the year, and the extent and overlapping of the districts. From these data, which we have prepared at no little trouble, our correspondent may be able to work out some such comparison. A difficulty which we perceived when calculating these tables was that the mere map of the streets in which mains are laid, and even an accurate plan of the whole network, gives no information as to the distribution of the lamps over the district. We have divided the number of supply units sold (as shown in our analysis of the Board of Trade returns) by the net area of the districts, as given in our new year's number, and the following is the result:—

	Supply units per sq. mile.
St. James	4,450,000
Kensington	575,000
Westminster	302,000
House-to-House	300,000
Metropolitan	272,000
Chelsea	257,000
Notting Hill	43,500

But this does not advance the matter much, since many of the districts were, and are still, far from being completely covered with mains.

We cannot quite agree with our correspondent that the essence of electric supply is distribution, and we think that distribution has attracted rather too much attention. Whatever the expenses of distribution may mean as given in the Board of Trade form of accounts, the average of the more prosperous London Companies for this item amounts to only 0·326d. per unit supplied. Distribution losses may mean only the C^2R losses, and no information has yet been published by means of which this waste in low-pressure or high-pressure mains, as used in practice, can be compared. If this information could be obtained it would afford a clue to the average distance of the lights from the generating centre. The losses in accumulators, resistances for regulating feeders, and dynamo losses must be deducted from the total waste in continuous-current work; and instead of the accumulator losses, the transformer losses must be taken into account in alternating-current systems in order to get at this C^2R loss.

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A THOROUGH series of tests on the life and efficiency of glow lamps has been recently made at the Ohio University by Prof. THOMAS and Messrs. MARTIN and HASSLER; and a comparison of the results arrived at, with those obtained at the Central Institution, and recently published in *The Electrician*, is instructive. The instruments used seem, in each set of tests, to have been exceptionally good, and the standard of light, a Methven screen, was the same for both. The London tests were made on a few lamps only, while at Ohio no less than 127 lamps were used, but as the former were all Edison-Swan lamps, and the latter consisted of many different types, the average is probably as reliable in one case as in the other. The tests agree in regard to the efficiency obtainable with new glow lamps when run at the normal candle-power. When this efficiency is expressed in the usual way, in watts per (mean horizontal) candle-power, its value for new lamps is 4·2 for the Ohio tests, and 4·3 for the tests made at the Central Institution; in other words, 70 watts are needed to incandesce a new 16-c.p. lamp to normal brightness, if these tests are correct, and in practice the power needed must exceed this, owing to the falling off of efficiency with the age of the lamp. The usually assumed number of 64 watts thus seems too small for lamps which are really giving a light of 16 candles, although we notice, on reference to the tests reported in our issue of July 15, that *one* of the lamps, No. 202, only needed 64 watts to raise it to its full candle-power. In practice the 64 watt limit is probably not exceeded, but this indicates that the lamps are not run at their nominal candle-power. This is certainly the explanation in the case of the American lamps, for the average candle-power of the 127 lamps, tested at the normal voltage, was found to be only 14·5 instead of 16. The evidence is not so conclusive as regards the English lamps, for these, when run at the proper voltage, were found in some cases below, and in others above, the nominal candle-power.

THE decrease of efficiency with age formed the chief object of the experiments made by Prof. THOMAS and his colleagues, and the exhaustive nature of their work carried out by them may be judged from the fact that the lamps were run continuously for two months. Few reliable tests on the life of glow lamps have yet been made, so that the measurements obtained are important. We reproduce in our present issue an abstract of these tests, the net results of which are that the candle-power of a glow lamp diminishes 10 per cent. after a run of 200 hours at constant voltage, and that the efficiency in watts per candle is 4·2 for a new lamp, 5·6 for a lamp after 600 hours use, and 7 after a 1,200 hours run.

WE have, in common with several local and daily papers, received the following indignant communication with reference to the proceedings of a riverside Local Authority:—

"The Chiswick Local Board obtained some time ago a Provisional Order under the Electric Lighting Acts. Absolutely ignorant of its value, they now propose to transfer their powers for £600 in cash. But that is not all. They propose to lease a magnificent site for a station for £1 per annum. Naturally those of the inhabitants who know anything about electricity are much dissatisfied, and steps are being taken to memorialise the Board of Trade to refuse its sanction to the arrangement. The issue of the Chiswick Electric Lighting Company is likely, therefore, to be postponed for the present."

For our own part we fail to see that there is anything to complain of from the profit and loss point of view. It is not probable that anything like £600 was spent in obtaining the Order in question; so that a satisfactory profit has been made on the transaction, and the nominal rent charged for the "magnificent site" is perhaps only an offset to advantages extracted from the venturesome electric light pioneers. On the other hand, this hawking about of Provisional Orders by speculating Local Authorities, while commendable from the commercial aspect, is scarcely in keeping with municipal dignity. With the Electric Lighting Acts and the Board of Trade Regulations at their back, Local Authorities are perfectly well able to safeguard the interests of the community without going to the trouble of obtaining powers which they do not mean to make use of themselves.

Moscow Electrical Exhibition.—This Exhibition was opened on the 9th inst.

Electric Traction in Austria.—Abbazia, a seaside resort on the Adriatic, is to be connected with the main line to Fiume by an electric railway two miles long.

Erratum.—The reference on page 241 of our issue of July 8th to Vol. XXVI., page 608, for a description of the hydro-electric plant at Tivoli, should read Vol. XXVII., page 608.

Bedford.—At a recent special meeting of the Town Council it was resolved to request the Board of Trade to revoke the Electric Lighting Order which the Council had obtained.

Cable Restorations.—

	Date of restoration.
Sierra Leone—Accra	July 21.
Capetown—Mossamedes	July 22.

Appointments.—Mr. W. H. Monk, Superintendent for Telegraphs at Manchester, to be Postmaster of Great Yarmouth; and Mr. J. Haynes, Telegraph Superintendent at Gloucester, to be Postmaster of Blackpool.

Dublin.—A few of the arc lamps which have now been established in the leading streets of Dublin were lighted about one o'clock on Wednesday for the purpose of testing the light. The experiment was a great success.

St. Pancras Vestry.—The electric light is to be further extended in St. Pancras. The Electric Light Committee of the Vestry have resolved to light Hampstead-road to High-street, Camden Town, one mile in extent, at a cost of £4,750.

Islington Vestry.—This vestry held a special meeting on Friday last to consider a report from Prof. Henry Robinson with reference to the electric lighting of their district, and it was unanimously resolved to apply for a Provisional Order.

Electric Lighting at Shanghai.—According to the *North China Daily News*, the Municipal Council of the Anglo-American Settlement at Shanghai have announced that no further permits will be granted for any extension of overhead wires, under any circumstances whatever; and the Council has been informed by the Company that it cannot put its wires underground.

The Electrical Utilisation of Water Power in France.—The little town of Dourgne, in the Department of the Tarn, has recently municipalised the water of Touron rivulet. Under ordinary circumstances this little stream only yields 15 to 18 litres per second (3·3 to 4 gallons per second); but a dam 20ft. high has given a reservoir of 1,500 cubic metres (53,000 cubic feet) capacity, and a 214ft. fall is obtained.

Mr. F. N. Gisborne.—In reference to the account of the death of Mr. Cyrus W. Field, which recently appeared in this Journal, it is interesting to note that only one survivor now remains of the group of incorporators in the famous Charter of 1854, of the New York, Newfoundland, and London Telegraph Company, viz., Mr. F. N. Gisborne.

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Personal.—At the Technological Examination held last May by the City and Guilds of London Institute, the Cordwainers' Prize and the Silver Medal were gained by Mr. Conrad K. Falkenstein, in the Tanning Section (Honours). Mr. Falkenstein has been devoting his attention during the last three years to the applications of electricity in the tannery, with the British Tanning Company.

Electric Traction Schemes in Paris.—The Conseil Municipal has adopted the proposed Berlier electric tubular railway scheme. A security of £20,000 will have to be deposited; there is to be a uniform fare of 2d., and no *employé* is to be paid less than 7d. an hour. The Government, it is stated, hold that the action of the municipality is *ultra vires*, and that the Legislature must be asked to give its sanction to the scheme.

Reciprocity.—Electricians have generally supplied themselves with gas in their boiler and engine rooms as a standby; but it has been reserved for Mr. Craven, the manager of the Corporation Gas Works at Dewsbury, to introduce the electric light into the pumping room. A small dynamo has been belted on to one of the pumping engines, and it gives all the light wanted with safety, and at no cost. This practice is being followed in various other places. This is a sign of the times. Even gas engineers are now embracing electricity.

Wolverhampton.—The Town Council have for some time been considering the advisability of putting into operation the powers conferred upon them by their Electric Lighting Order. The Lighting Committee prepared a report which has been submitted to a private meeting of the Council, and the scheme has been unanimously adopted. The price of the unit is taken at 6d., and the report of the Borough Surveyor and Mr. Harold Dickinson contain recommendations involving an expenditure of £37,000. It is proposed to immediately erect a 10,000 light station with an ultimate capacity of 50,000 lights.

The Preservation of Accumulator Plates.—The following is M. G. Darrieus' recipe for keeping the plates of accumulators in a healthy condition when the cells are left idle for a long time. After being well charged, the plates should be carefully washed, and then placed in a neutral solution of sulphate of soda. Before use they should be charged *in* the sulphate of soda, and then replaced in a sulphuric acid solution. "An already lengthy experience of this process," says M. Darrieus in *L'Industrie Electrique*, "enables me to strongly recommend it."

A Workshop Wrinkle.—The use of an electric arc, as employed in the Benardos welding process, may be often adapted for other purposes in which a local application of heat is required. A correspondent writes to the *English Mechanic*, describing the breaking of a tap in a ½in. hole in the end of a shaft. After trying unsuccessfully to soften it with a blowpipe, he connected the shaft to a dynamo, and forming an arc with a carbon, a current of 30 to 40 amperes brought the end of the shaft to a dull red in about three minutes. When cooled the tap was easily drilled out.

Communication with Lighthouses.—The Royal Commission for inquiring into electrical communication with lighthouses and lightships met again on Thursday last week, at 21, Northumberland-avenue. Lord Mount-Edgcumbe presided. After considering the various methods proposed for the establishment of communication by telegraph with lighthouses and lightships on the Scotch coast, the Commissioners decided to make a tour of inspection of lighthouses, beginning in the latter part of August at the Goodwin Sands and the mouth of the Thames, and proceeding along the coast to Cromer. Visits will also be made to the Bristol Channel and the Scilly Isles.

Dover.—The following is the gist of the agreement come to between the Town Councils of Canterbury and Dover and the Brush Electrical Engineering Company, alluded to on p. 299 of our last issue. The name of the Company is to be "The Dover and Canterbury Company." Two accounts are to be kept, and the chief office is to be at Dover. It was agreed to allow the Company to debit the annual accounts with 7½ per cent. for depreciation until a sum equal to one quarter of the capital has been reached. In the matter of the accumulated dividend this is to be 10 per cent. before a reduction of price to consumers becomes compulsory. The penalty to be paid by the Company for lamps out will be 5s. per lamp per night.

Electric Lighting on Shipboard.—Considerable capital has been made in some quarters out of the recent accident on the French battleship, "Dupuy-de-Lôme," the extinction of the electric light, it was alleged, being the cause of the accident. According to *La Lumière Electrique*, the facts of the case were as follows:—One of the boiler stays having yielded 15mm., there was an escape of steam. A panic ensued, and the stokers precipitated themselves towards the ladders, and three gauge-cocks somehow got opened. The steam invaded the dynamo room, and the attendant, thinking discretion the better part of valour, shut down the dynamos and electric steering gear apparatus and departed, with the result that the ship was left in darkness and unmanageable.

The Physiological Effects of Sinusoidal Currents.—In a recent communication to the Académie des Sciences, M. d'Arsonval states that, according to experiments made by him, it would appear that by spreading out the sinusoidal current curve we may pass fairly strong currents through the human body without causing pain, muscular contraction, or chemical action. This absence of all physiological action is, however, only apparent, since analyses of the respiratory gases show that the passage of the current is accompanied by an increased absorption of oxygen and an increased elimination of carbonic acid. By augmenting the frequency powerful muscular contractions are provoked, which are, however, less painful than those caused by the irregular variation of an induction-coil current.

A Real Electric Locomotive.—"It has yet to be proved," says the *Engineer*, "that it is possible to make an electric motor which will comply with all the multifarious conditions inexorably dictated by the exigencies of traffic. In the United States nothing of the sort has yet been produced, and it is fair to assume that they know as much at the other side of the Atlantic as is known at this about electricity. Apparently a very wide departure from existing methods and principles of construction may be needed to secure success, and no one can say that the field of invention in this direction is nearly filled. It seems, however, to be almost time that someone with the requisite knowledge and ingenuity set himself in earnest to the work of designing a real electrical locomotive."

Packing Machinery.—Whitelead and tallow is commonly used to protect bright parts of machinery in transit; but neither this nor the specially-prepared greases will stand a voyage to Brazil, Chili, South Africa, or Australia. Tropical heat either hardens the protective substance, so that it becomes very difficult to remove, or it fails to hold, and blisters or scales off. In the "Machine-shop Notes" of the *Engineering Magazine* of New York for this month directions are given for making "tar-lined" boxes. "Kiln-dried pine lumber" may, perhaps, be used in this country, but not under such a name; the pieces are to be "cleated," probably meaning dowelled together, and the sides are to be painted with "hot rock asphaltum." While hot, thick tough paper is to be pressed on to the pitch, and a second coat is to be applied hot both to the interior and between the joints.

Electric Lighting Notices.—Notices of intended application for Electric Lighting Provisional Orders have been served upon the following Local Authorities by the following Companies:—Cork Town Council, Cork Gas Consumers' Company; Newmarket Local Board, British Electric Light Company; Rotherhithe Vestry, County of London Electric Lighting Company; St. George's-in-the-East Vestry, County of London Electric Supply Corporation; Weymouth Town Council, Aurora Electric Lighting and Distribution Company; Ryde Town Council, Aurora Electric Lighting and Distribution Company. This Company proposes to supply electricity at 6d. per B.T.U. The recommendation of the Public Works Committee that the application be refused has been adopted unanimously, it being explained that the object of the resolution was merely to give the Council a *locus standi*.

Town Councils and Electric Lighting.—The following extracts from a circular, emanating from the Town Clerk's

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office, Wigan, may be taken as a sample of the way in which electric lighting enterprise is often covertly snuffed out by Local Authorities in possession of Electric Lighting Orders which they neither wish to make use of themselves or allow others to use :—

Dear Sir: You are doubtless aware of the fact that in 1890 the Corporation obtained a Provisional Order for the supply of electric lighting to the town; but as it did not appear at the time the powers were granted to be any general desire on the part of the public to have such light in preference to cheap and good gas, no electric works were laid down by the Corporation. They think it right, however, to state that they are prepared to undertake the supply in the following streets . . . if such be the wish of the ratepayers, subject to all the restrictions imposed by the Provisional Order for ensuring safety and efficiency. I am, therefore, to inquire whether you will agree to take the electric lighting if provided by the Corporation for a fixed period of three years, at a reasonable price, say 6d. per unit, or double the price of gas-light per light. To lay down suitable plant will be costly, and you, as a ratepayer, would not like the expense to be incurred unless there is a reasonable prospect that it will not be a serious loss. Your early reply on the enclosed postcard will be esteemed a favour, so as to enable the Corporation to determine as to what course they should adopt.

The Gresham University.—The Committee formed last January to oppose the grant of the Gresham University Charter have drawn up and submitted to the new Royal Commission a memorandum embodying the points which, in their opinion, are of special importance for the satisfactory construction of any new scheme. It is suggested that the Council should include, in addition to nominees of the Crown, a representation of the teaching staff of the institutions in London giving teaching of University rank. The Professors and other teachers of the University should be grouped into Faculties, with such consultative and administrative powers as shall be determined by the Council, the examiners of the University to be members of the Faculties *ex officio*. It is proposed that there shall be a strong Professoriate, with a sufficient staff of lecturers and demonstrators. The appointment of University teachers should be vested in all cases not in the Colleges, but in the Crown or in the University itself, either directly through the Council or through electing Boards appointed for the purpose. If the University is to do any considerable work it is pointed out that there must be liberal assistance from public sources, such as the Consolidated Fund, the County Council Funds, the City Companies, and the City Parochial Charities. It is suggested that the existing University of London should be remodelled, and that the new University should be empowered to confer degrees in theology.

The Rival (?) Telephone Companies.—An esteemed correspondent writes us as follows :—

"The New Telephone Company, which has this week emerged into a new phase of existence, has had a strangely chequered career. Founded in 1884 to work the 'Valve' Telephone of Prof. S. P. Thompson, it succeeded in gradually establishing a business in the sale of these instruments, and of a modified form devised by Mr. White, in the teeth of the opposition of the United Telephone Company, who then held the Bell and Edison patents, and had established a reign of terror over all rivals. In 1889, however, just as the New Telephone Company's affairs were blossoming into success, it was sued by the United Telephone Company for infringement, it being alleged that the White pattern of transmitter was within the Edison patent. Without defending the action, the New Telephone Company's Directors succumbed at once, and were compelled to surrender not only the instruments attacked, but also all their 'valve' transmitters of older pattern and all their receivers. To avoid vexatious litigation, the New Company went into liquidation, but after some months paid its trade creditors in full, and the liquidation was annulled. At this stage their affairs, and their principal asset—the licence of the Postmaster-General—passed into the hands of new Directors, who proceeded to reconstruct the Company, and to inaugurate a more vigorous policy. They entered into an agreement with the City of London Electric Lighting Company for the use of its spare ways and conduits underground in the City. They acquired the Mutual Exchange at Manchester. They entered into negotiations with other electric lighting companies in London for underground wayleaves. The National Telephone Company, foreseeing the crisis which its resuscitated rival would assuredly provoke when its underground service with twin-wires should be completed, hastened to make terms with its once-vanquished competitor. It has not only subscribed for one-third of its capital, and agreed to allow the subscribers of the New Telephone Exchange to connect up to those of the existing exchange, but has even sent four of its Directors to join the new Company's Board. The next development will be awaited with some interest."

The Electrolysis of Silver Nitrate in Vacuo.—In a Paper recently read before the Royal Society, Prof. Schuster and Mr. A. W. Crossley state that they undertook some investigations in order to clear up some minor irregularities which occur in the measurement of current by means of the silver voltameter. These anomalies are the slightly heavier deposit obtained from a warm solution and the discrepancy between deposits taken simultaneously in platinum bowls of different sizes. The Paper dealt, however, mainly with the fact discovered by the authors that deposits obtained *in vacuo* are somewhat larger than when the electrolysis is conducted in voltameters exposed to air at the ordinary pressure. The authors trace this difference to the effects of dissolved oxygen, for when the electrolysis was carried out in an atmosphere of oxygen the deposits were less than those obtained in air. The apparatus employed to obtain a deposit *in vacuo* was an inverted bell jar, closed at the bottom by a rubber stopper, at the top by a plate of glass. The jar contained a tight-fitting cylindrical cage of wire gauze. The platinum bowl was placed on two copper rods, soldered to the cage, to which one of the battery wires was connected. The anode was suspended from a glass rod. The large platinum bowl was 5in. in diameter, and the small one 3½in., the anodes were about 2mm. thick. The authors obtained a consistent difference of about 0·02 per cent. in favour of the larger bowl. Some experiments seemed to show that when *anodes* of the same size are used this discrepancy disappears, confirming the impression of the authors that the effect may possibly be due to secondary products found at the anode when the current density exceeds a certain value. The results of similar experiments *in vacuo* were not very concordant; but the average deposits were heavier in the large bowl. The electro-chemical equivalent of silver as deduced from electrolysis *in vacuo* was almost identical with that obtained in Lord Rayleigh and Mrs. Sidgwick's deposits from hot solutions. The experiments showed a small but very consistent polarisation of seven millivolts, which was the same in air and *in vacuo*. The authors conclude from their experiments that the true electro-chemical equivalent of silver is probably not quite one part in a thousand greater than the value given by Lord Rayleigh.

Ceylon as a Source of India-Rubber Supply. — At the London Chamber of Commerce on Monday last Mr. J. Ferguson, the corresponding Secretary to the Colonial and Imperial Institutes in Ceylon, gave an address on "Tropical Agriculture in that Colony." Dealing with the india-rubber plant, he thought there was much encouragement for the Ceylon planter to take up this product, for which he understood there was a large and growing demand at remunerative prices, especially as the prospects of the supply from South America, Africa, and the East (nearly all forest trees), was gradually falling off, or at any rate was below the requirements of manufacturers. If it was true, as he had learned, that one province of Para in Brazil had developed an export equal to 17,000 tons per annum in a favourable year, and worth £300 a ton, or £5,000,000, all the rubber being got from systematic tapping of the trees, there ought certainly to be room in Ceylon for extensive planting experiments with a view to the supply of the future. In Ceylon no little attention had been given to the cultivation of caoutchouc, or india-rubber, trees over a dozen years ago, when they had been hard pressed for products to take the place of coffee; and for some years great hopes were expressed that the industry would become a profitable and permanent one. Sample parcels of Ceylon Ceara rubber harvested from trees eight to ten years old, sold as high as 4s. per pound. But the great rush into tea, and the greater ease with which returns could be got from that product, together with the long time required by rubber trees to mature, and the greater expense in tapping and harvesting, discouraged further planting; and he could not speak of more than 450 acres in all Ceylon as now being cultivated with rubber plants, although of late years Dr. Trimer had been able to report very favourably on experiments under his direction in the Botanical Gardens, and attempts were now being made by the Ceylon Forests Department to grow the tree in jungle clearings. The Gardens had also sent plants and seeds to North Borneo and East Africa. In Colombo they had endeavoured to bring all the information about rubber into a Planters' Manual, and there could be little doubt that if the Ceylon Garden and Forest experiments went on well during the next few years, planters would once more take up the industry.

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ELECTROMAGNETIC THEORY.—XXXIII.

BY OLIVER HEAVISIDE.

(*Continued from page 275.*)

§ 153. All the above analogies, however good or bad they may be in other respects, are deficient in one vital property, inasmuch as they involve the elasticity of distortion, and with it, the energy of distortion. But the electromagnetic equations, especially when put in the duplex form symmetrical with respect to the electric and magnetic sides, have nothing in them suggestive of distortional forces, nor can we represent either the electric or the magnetic energy as the energy of distortion. On the other hand, the equations are fully suggestive of rotation. If, then, the elastic solid has still to do duty for purposes of analogy, and yet not fail upon the point mentioned, it is clear that the rigidity must be done away with, at least as an electromagnetically active influence. Its place must then be taken by elastic resistance to rotation, by using a rotational instead of a shearing stress. This brings us to the medium invented by Lord Kelvin, called by him simply Ether, and contrasted with Jelly, which means an incompressible elastic solid with ordinary rigidity. This rotational ether has mass of course, for one thing, which brings in kinetic energy (of translation); and, on the other hand, it possesses, by means of internal arrangements with which we are not immediately concerned, the property of elastically resisting rotation, and consequently stores up energy of the potential kind, to balance the kinetic. If this were all, there would be little more to say. But Lord Kelvin found that his Ether enabled him to complete a long-delayed work, viz., to produce a satisfactory elastic-solid analogy to suit the problem of magnetic induction ("Mathematical and Physical Papers," Vol. I., art. 27, and Vol. III., art. 49); and I have pointed out that this rotational ether enables us to construct good all-round analogies for the propagation of disturbances in a stationary dielectric (Appendix to chap. II., *ante*), with correct localisation of both energies and of the flux of energy. As these are the only all-round elastic-solid analogies yet known, we may here consider them again, especially in relation to the previously given analogies, and to show where the changes come in.

Go back to equation (313), giving the translational force $\mathbf{F}$ due to the stress in an elastic solid when there is rotational elasticity as well as rigidity. We have

$$\mathbf{F} = n(\nabla^2\mathbf{G} + \tfrac{1}{3}\nabla \operatorname{div}\mathbf{G}) + k\nabla \operatorname{div}\mathbf{G} - \nu \operatorname{curl}^2\mathbf{G}, \quad (346)$$

where $\mathbf{G}$ is the displacement, n the rigidity, k the compressive resistivity, and ν the new elastic constant connected with the rotation. Now, we have $\operatorname{curl}^2 = \nabla \operatorname{div} - \nabla^2$, so we may rearrange (346) thus,

$$\mathbf{F} = (n+\nu)\nabla^2\mathbf{G} + (k + \tfrac{1}{3}n - \nu)\nabla \operatorname{div}\mathbf{G}, \quad . \quad (347)$$

and this may be split up into circuital and divergent parts, viz.,

$$\mathbf{F}_1 = (n+\nu)\nabla^2\mathbf{G}_1, \quad \text{(circuital)}, \quad . \quad (348)$$

$$\mathbf{F}_2 = (k + \tfrac{4}{3}n)\nabla^2\mathbf{G}_2, \quad \text{(divergent)}. \quad (349)$$

Now observe that in the circuital equation, n and ν occur additively, so that equal parts of each have the same effect, and either may be replaced by an equal amount of the other. This is irrespective of the compressibility, which is not concerned in circuital disturbances. We see, then, that the rigidity may be done away with altogether and equal ν substituted, without affecting the propagation of circuital disturbances. This is a very remarkable property.

Observe, also, that in the divergent equation ν does not enter at all, although n does, and in the same way as in the ordinary compressible rigid solid. In fact, the coefficient $k + \frac{4}{3}n$ is the same as the former $m+n$, of § 142 and later. So the propagation of divergent disturbances is the same as if the rotational elasticity were done away with.

Now, we have already noticed the case in which the speed of the divergent wave is brought down to zero—the contractile ether of §§ 142, 143. In an ordinary rigid solid, which was then referred to, this requires negative compressibility. But now, if n be abolished and ν substituted, so that the circuital propagation is unaffected, the divergent equation will contain only k, so that to make the speed of the divergent wave zero we need only abolish the resistance to compression, or make $k=0$. The medium does not now resist either change of shape or of size, but resists rotation only, and the potential energy is the energy of rotation. This is one extreme form of the rotational ether, made by combining it with the contractile, by the evanescence of the rigidity and of the resistance to compression. The medium is quite neutral as regards expansion and compression.

Now, it is clear, from equation (348) and matter in previous paragraphs, that we may construct analogies to suit the non-conducting dielectric by abolishing n and using ν instead, without concerning ourselves with k at all, which may have any value from zero to infinity. But Lord Kelvin's ether is got by going to the other extreme from the neutral case just mentioned.

§ 154. Take $k=\infty$ (with $n=0$) making the medium incompressible, and therefore making disturbances in an unbounded medium be necessarily circuital, whether the impressed forcive be circuital or not. We now have

$$\mathbf{F}_1 = \nu\nabla^2\mathbf{G}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (350)$$

by (348), whilst the other equation (349) will merely assert that $\mathbf{F}_2$ is balanced by difference of pressure. This we are not concerned with, since our impressed forcive should be circuital in the electromagnetic comparisons. The stress (310) is now

$$\mathbf{P}_N = -\nu\mathbf{V}\mathbf{N}\operatorname{curl}\mathbf{G}, \quad . \quad . \quad . \quad . \quad (351)$$

where we ignore the uniform pressure for the reason mentioned. The torque accompanying this stress is, by (311),

$$\mathbf{S} = 2\nu \operatorname{curl}\mathbf{G}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (352)$$

and the translational force is

$$\mathbf{F} = -\operatorname{curl}\tfrac{1}{2}\mathbf{S} = \nu\nabla^2\mathbf{G}, \quad . \quad . \quad . \quad (353)$$

agreeing with (350). So the equation of motion is, by (306),

$$\mathbf{f}_1 = (\rho p^2 - \nu\nabla^2)\mathbf{G} = (\rho p - \frac{\nu}{p}\nabla^2)\mathbf{q}, \quad . \quad . \quad (354)$$

where $\mathbf{f}_1$ is the circuital impressed force, and $\mathbf{q}$ is the velocity. As before, we keep to small motions in general.

Equation (354) may be at once compared with the electromagnetic

$$\mathbf{f} = \left(\mu p - \frac{\nabla^2}{cp}\right)\mathbf{H} = \left(\mu p^2 - \frac{\nabla^2}{c}\right)\mathbf{Z}, \quad . \quad . \quad . \quad . \quad . \quad (355)$$

as in (325), (326), our first example, and we therefore deduce the following correspondences:—

	$\mathbf{Z} = \mathbf{H}/p$	stands for	$\mathbf{G}$,	(spacial displ.)
(mag. force)	$\mathbf{H}$	,,	,, $\mathbf{q}$,	(velocity).
(el. current)	$\operatorname{curl}\mathbf{H}$	,,	,, $\operatorname{curl}\mathbf{q}$,	(2 × spin).
(el. displ.)	$\mathbf{D}$	,,	,, $\operatorname{curl}\mathbf{G}$,	(2 × rotation).
(inductivity)	μ	,,	,, ρ,	(density).
(permittivity)	c	,,	,, $1/\nu$,	(rotl. compliancy).
(induction)	$\mathbf{B}$	,,	,, $\rho\mathbf{q}$,	(momentum).
(el. force)	$\mathbf{E}$	,,	,, $\frac{1}{2}\mathbf{S}$,	($\frac{1}{2}$torque).
(mag. energy)	$\frac{1}{2}\mu\mathbf{H}^2$	,,	,, $\frac{1}{2}\rho\mathbf{q}^2$,	(kin. energy).
(el. energy)	$\frac{1}{2}c\mathbf{E}^2$	,,	,, $\frac{1}{2}\nu(\operatorname{curl}\mathbf{G})^2$,	(rotl. energy).
(source of $\mathbf{H}$)	$\mathbf{f} - \operatorname{curl}\mathbf{e}$	,,	,, $\mathbf{f}_1$,	(impd. force).
(energy flux)	$\mathbf{V}\mathbf{E}\mathbf{H}$	,,	,, $\mathbf{V}\frac{1}{2}\mathbf{S}\mathbf{q}$,	(energy flux)

Referring to the similar list in § 146, it will be seen that the correspondences there given are repeated here, except that the elastic constant changes its meaning, and that there are now additional correspondences. The electric energy is correctly localised by the potential energy of the rotation. Since the kinetic energy is also correctly localised, we need not be surprised to find that the energy-flux has the same distribution.

The activity of the stress $\mathbf{P}_N$ is $\mathbf{P}_N\mathbf{q}$ per unit area, which is the same as $q\mathbf{N}\mathbf{P}_q$, if $\mathbf{P}_q$ be the stress on the plane whose normal is $\mathbf{q}$, provided the stress is irrotational. But if rotational, as at present, it is $q\mathbf{N}\mathbf{Q}_q$, where $\mathbf{Q}$ is conjugate to $\mathbf{P}$. This activity means energy transferred from the side of the plane when the stress vector is reckoned, to the other side, or against the motion. The vector expressing the energy flux is

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therefore $-q\mathbf{Q}_q$, not counting the convective flux. In our present case, by (351), $\mathbf{Q}$ is the negative of $\mathbf{P}$, because it is purely a rotational stress, so $\mathbf{W}=q\mathbf{P}_q$ is the vector flux of energy; or, by (351),

$$\mathbf{W}=-\nu q\mathrm{V}\mathfrak{q}_1\operatorname{curl}\mathbf{G}=-\nu\mathrm{V}\mathfrak{q}\operatorname{curl}\mathbf{G}, \quad . \quad (356)$$

which is, by the above table, the same as $\mathbf{VEH}$, the electromagnetic flux of energy. (In the above, q and $\mathfrak{q}_1$ are the tensor and unit vector of $\mathfrak{q}$.)

The above reasoning is applied directly to the unit element of volume. But it may be easier to follow by taking any volume into consideration. If $\mathbf{N}$ is the normal outwards from the surface enclosing it, then $\mathbf{P}_N$ is the pull, per unit area, of the matter outside, on the matter inside the surface, across the unit area of the interface; and $\mathbf{P}_N\mathfrak{q}$ is its activity. The total activity of $\mathbf{P}_N$ all over the surface is therefore $\Sigma\mathbf{P}_N\mathfrak{q}$, which is the same as $-\Sigma\mathbf{N}q\mathbf{P}_q$, and expresses the work done per second by the matter outside on the matter inside the surface, or the rate of transfer of energy from the outside to the inside; and its equivalent is the rate of increase of the stored energy, potential and kinetic, within the surface. The convergence of the vector $q\mathbf{P}_q$ expresses the same property for the unit volume, so that $q\mathbf{P}_q$ is the flux of energy (per unit area) itself. (The small convective flux of energy is ignored here.)

§ 155. That *any* circuital flux of energy may be superadded, without making any difference in the transformations of energy, is a fact which is of importance as evidence against the objectivity of energy, but is of no moment whatever in the practical use of the idea of a flux of energy for purposes of reasoning. We should only introduce an auxiliary circuital flux when some useful purpose is served thereby.

I may here remark that (speaking from memory) when Professor J. J. Thomson first objected to the $\mathbf{VEH}$ formula as representative of energy-flux, by reason of the circuital indeterminateness, he added that a knowledge of the real flux could only be determined from an actual knowledge of the real dynamical connections involved, that is to say, by a knowledge of the mechanism. But this is surely an inconclusive argument, because the circuital indeterminateness applies even then. In fact, it is universal in its application, as energy is at present understood. For there to be an absolutely definite flux of energy through space seems to require energy to have objectivity in the same sense as matter, which is a very difficult notion to grasp, and still more difficult to accept. But even if it be accepted, the argument of circuital indeterminateness remains in action, when it is desired to find what *is* the flux in a given case.

In a recent number of the *Phil. Mag.*, Mr. Macaulay, by the addition of a certain circuital flux to $\mathbf{VEH}$, brings out the result that in stationary states the modified flux reduces to $p\mathbf{C}$, where p is potential and $\mathbf{C}$ current-density. I am, however (unless I forget much of what I have learnt in the last 15 years), unable to see that the auxiliary flux proposed serves any useful purpose. In the first place, it greatly complicates the flux of energy in general, and is entirely against the more simple ideas to which we are naturally led in the study of electromagnetic waves, whether in dielectrics or conductors. Besides that, it is implied that the function p, or electric potential, is a determinate quantity specifying some definite state of the medium. This seems to me to be an idea which has no place at all in Maxwell's theory. It may have place in other theories, but that is not to the point. To exemplify, put a closed circuit (with battery) supporting a steady current inside a metal box, and electrify the latter from outside. According to the $p\mathbf{C}$ formula, the flux of energy in the wire suffers a very remarkable change, by reason of the raising of the potential of the box and its interior. But, according to the interpretation of Maxwell's scheme which I expound, there is no change whatever in the electrical state of the interior of the box in the steady state (though there may and must be a transient disturbance in the act of charging it, which is a separate question), and the energy distribution and its flux are the same as before, because $\mathbf{E}$ and $\mathbf{H}$, which settle the state of affairs, electric and magnetic, are unchanged. There are, however, I believe, some electricians who will be much gratified with the $p\mathbf{C}$ flux in steady states.

The total flux of energy through a wire will be $p\mathrm{C}$, where by C we mean the total current, obtained from $p\mathbf{C}$ by integration over the cross-section. Now this is somewhat suggestive of my expression VC for the total flux of energy along a circuit of two conductors. But there are radical differences. For VC is the integral form of $\mathbf{VEH}$ in the dielectric. Although C in VC means the same as in $p\mathrm{C}$, being the circuitation of $\mathbf{H}$, or the gaussage, V has no connection with p the potential, for it (V) is the line-integral of $\mathbf{E}$ across the circuit from one wire to the other—*i.e.*, the transverse voltage. Again, the VC formula holds good in variable as well as in steady states, whilst the proposed $p\mathrm{C}$ holds for steady states only. Even in steady states, when V specializes itself and becomes difference of potential, it remains different from p.

But although I cannot see the utility of the proposed change, which seems to be a retrograde step, I think that Mr. Macaulay's mathematics, which is of a strong kind, may be of value in the electromagnetic field in other ways, especially when cleared of useless and treacherous potentials.

§ 156. Returning to the suppositional Ether, the conception is of an incompressible medium possessing mass, which involves translational inertia, and therefore kinetic energy, and which elastically resists rotation, and so stores potential energy; and we have supposed that the velocity of the medium means magnetic force, and that its density means μ, so that the kinetic energy and the magnetic energy are compared. But we may equally well have this comparison of the energies combined with a different interpretation of μ. Take, for instance, the induction to mean velocity. Then, since the magnetic energy is $\frac{1}{2}\mu^{-1}\mathbf{B}^2$, we see that it is now, not μ, but μ^{-1} that is the density, whilst $\mathbf{H}$ is momentum. Also, since $\mu c v^2=1=\rho\nu^{-1}v^2$, we see that the new interpretation of c is νv^{-2}. That is, the change of μ from density to its reciprocal involves the change of c from compliancy to its reciprocal, multiplied by v^{-2}, making ρ^2/ν. But it is better to write them out side by side, thus:—

(mag. energy)	$\frac{1}{2}\mu^{-1}\mathbf{B}^2$	stands for		$\frac{1}{2}\rho\mathfrak{q}^2$,	(kin. energy).
(induction)	$\mathbf{B}$	,,	,,	$\mathfrak{q}$,	(velocity).
(reluctivity)	μ^{-1}	,,	,,	ρ,	(density).
(mag. force)	$\mathbf{H}$	,,	,,	ρq,	(momentum).
(el. current)	$\operatorname{curl}\mathbf{H}$	,,	,,	$\rho\operatorname{curl}\mathfrak{q}$,	
(el. displ.)	$\mathbf{D}$	,,	,,	$\rho\operatorname{curl}\mathbf{G}$,	
(permittivity)	c	,,	,,	$\nu^{-1}\rho^2$,	
(el. force)	$\mathbf{E}$	,,	,,	$\nu\rho^{-1}\operatorname{curl}\mathbf{G}$,	
(el. energy)	$\frac{1}{2}c\mathbf{E}^2$	,,	,,	$\frac{1}{2}\nu(\operatorname{curl}\mathbf{G})^2$	(potl. energy).

The potential energy still correctly localising the electric energy, in spite of the other changes, we may expect the flux of energy to be correct. We have

$$\mathbf{VEH}=\nu\rho^{-1}\mathrm{V}\operatorname{curl}\mathbf{G}.\rho\mathfrak{q}=-\nu\mathrm{V}\mathfrak{q}\operatorname{curl}\mathbf{G},$$

as before, equation (356).

Similarly, we may assume that μ is not the density, nor its reciprocal, but an unstated function of the density, say $\mu=f(\rho)$, and work out the various correspondences that this necessitates. We shall, for example, by the formulæ for magnetic and kinetic energy, require

$$\mathfrak{q}=\mathbf{H}\{\rho^{-1}f(\rho)\}^{\frac{1}{2}}.$$

Of course, in thus comparing magnetic with kinetic energy, we shall always have $\mathbf{H}$ compared with $\mathfrak{q}$, or with some multiple of $\mathfrak{q}$, which may change its "dimensions," as, for example, in the above detailed cases, where $\mathbf{H}$ is changed from velocity to momentum.

Corrections.—In equation (319), for $\mathbf{D}$ read $\mathbf{G}$. In (320) and (321), delete the $\frac{1}{2}$ before ν_1 and k_1.

(To be continued.)

THE LOVE ELECTRIC TRACTION CONDUIT.

While the hot battle for and against the overhead trolley has been going on between the street car companies and the Municipal Authorities in various cities, resulting, in New York and Chicago, in the adoption of the cable, a street car company in the latter city has, says the *Electrical World*, been

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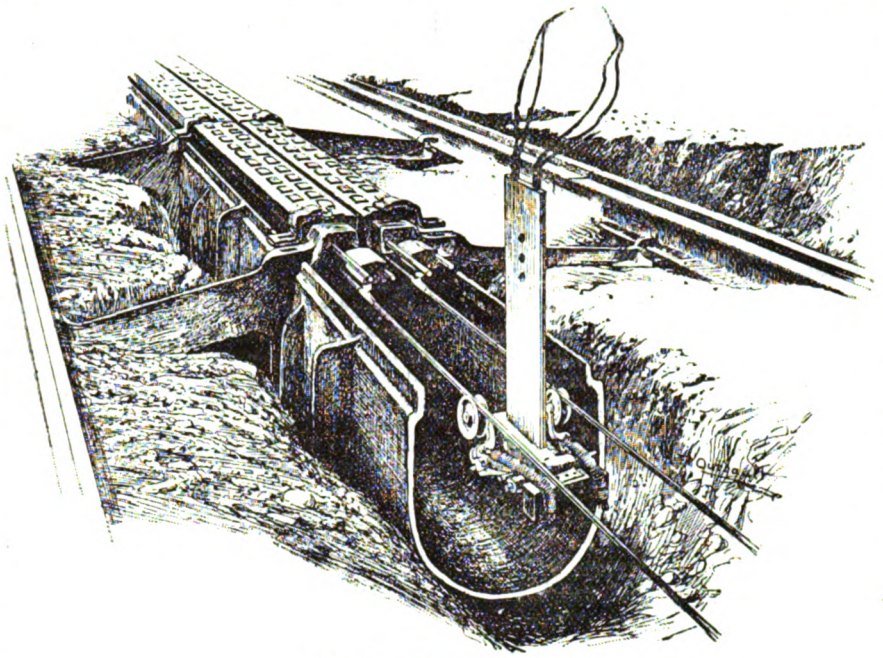
experimenting quietly with a conduit electric road in order to satisfy itself on the question of the possibility of working such a road successfully. This road has now been running some months.

The conduit used is that known as the Love system. One of the important features is that the top cover of the conduit (*see* Fig.) consists of rolled steel strips or angle irons, having a deep vertical flange on the side bounding the slot. These angle-irons are laid in long lengths, being secured in place by the clamps shown; by releasing these fastenings, which is a very simple matter, the angle-irons are readily removed, which opens the conduit and renders it easily accessible for examining and repairing the wires, cleaning the conduits, and other purposes. The flange on the slot side extends lower down than the wires, and therefore protects them in a measure from interference. It will be noticed, too, that both lead and return are insulated. One of the parts which was very troublesome at first was the trolley itself; but the simple form of trolley shown, which is the one used now, is perfectly satisfactory. The trolley wheels are slightly smaller than those used on overhead roads, and are loosely supported so as to admit of a small amount of play in all directions, just enough to adapt themselves to the inevitable slight irregularities, chiefly at curves. The whole trolley bar is easily detached and replaced if broken. The conduit is well drained by means of frequent pipe connections to the sewers and settling boxes. In order to clean it of mud and other sediment, a brush is attached to the trolley, which sweeps the dirt into receiving boxes.

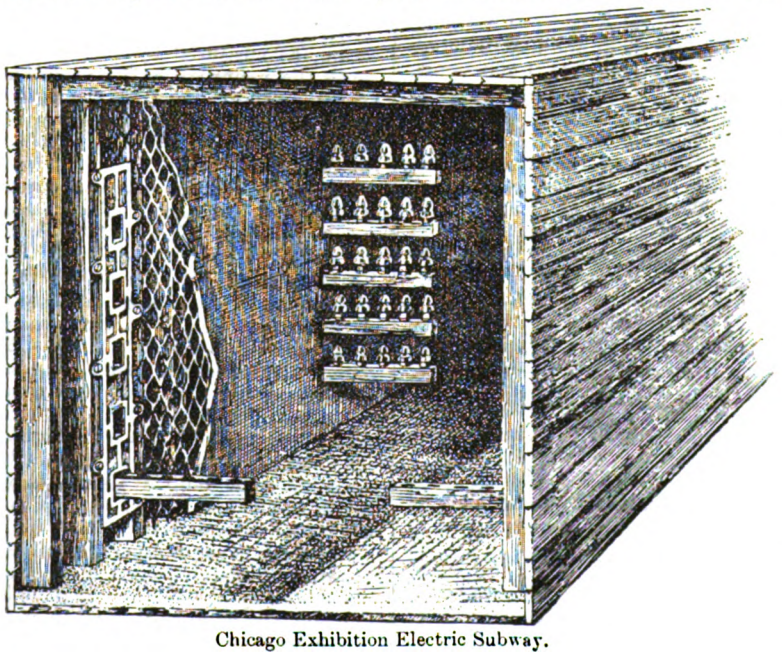


The Love Electric Conduit.

The road is one and five-eighth miles long, embracing four curves of 35°, 45°, and 55° radius, two double and two single track crossings and 10 switches. It was built during the past winter on the tracks of the North Chicago Street Railway Company. That the road has been running successfully is best shown by the fact that the North Chicago Street Railway Company has accepted the road. In a letter from President Yerkes, of that Company, he says:—"So far as the system itself is concerned it gives us perfect satisfaction, and contrary to my fears the insulation is not interfered with in any manner by moisture. We have had some of the most severe rains in this vicinity during the past three or four months that I have ever experienced, so much so that at one time the cars ran through water on the track three or four inches deep, the trolley in the conduit running in the water, owing to the inability of the sewer connections to carry off the flood fast enough, but at no time was the road stopped from this cause." After referring to some unfavourable points in the construction, he says, "with proper construction I believe the Love system would be a great success. . . . We have demonstrated that we could operate five times the number of cars that we are now doing with practically the same expense. . . . Your claim that your system is free from danger to the public is fully sustained."

THE ELECTRIC LIGHTING CONDUIT IN THE CHICAGO EXHIBITION GROUNDS.

To provide for carrying the immense number of wires from the central-power station in the Machinery Hall in the Exhibition grounds to the Electrical and other Buildings where current is to be used, an immense conduit 6½ feet square has, says the *Electrical World*, been built directly under the Machinery Hall. This conduit extends across the grounds only very slightly below the surface to the Electrical Building, from which branches are carried to other sections of the grounds. The accompanying illustration gives a good idea of the construction of this conduit. It has a timbered framework, and is completely enclosed by thick planking spiked to the framework on the outside. The studding, a part of which is shown at the left of the illustration, is composed of 3in. by 6in. timbers, set about 9in. or 10in. apart. The arms for carrying the wires are attached to the cribwork by means of cast iron socket frames, which are attached by heavy lag screws to the studding, as shown in the illustration. These iron frames are made with a number of deep sockets, into which arms are driven, and which afford a broad and ample bearing surface for their support. The arms are driven back against the planking on the outside of the cribwork. Over the inside of the studding is placed a covering of latticework, shown in the illustration, to which is attached an artificial



Chicago Exhibition Electric Subway.

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plaster board, so that the framework of the conduit is entirely sealed. On the cross arms are carried ordinary insulators, to which the cables are attached in the usual way. Arms are carried on both sides of the conduit, and are just long enough to leave space in the centre for a man to walk through conveniently whenever it is necessary to inspect the wires or to make any repairs. The floor of the conduit is slightly V-shaped to carry off any water which may get into the conduit. The illustration shows the entrance to the conduit directly under the power house. The whole construction is substantial, inexpensive, and permits of ready access to the wires which are carried through the subway.

A LIFE AND EFFICIENCY TEST OF INCANDESCENT LAMPS.*

BY PROF. B. F. THOMAS AND MESSRS. P. MARTIN AND R. H. HASSLER.

There is a great divergence between the published claims of lamp makers and the statements of the experience of station managers. Makers generally say that they will guarantee 600 hours' life for their lamps, and from 10 to 14 or more lamps per horse-power; but some station managers insist that they do not get an average of 400 hours' life. Considering it of prime importance for our object that the lamps tested should be of the same character as those usually sold to consumers, we bought some lamps of regular dealers, as in the usual course of business, and obtained others from lots supplied for central-station use. Lamps of the following makes were obtained, no attempt being made to get lamps of any given efficiency of any make:—A. B. C., Beacon, Columbia, Economic, Packard, Pennsylvania, Standard, Thomson-Houston, Edison, Perkins, Sawyer-Man, and Steuben. In ordering (through persons purchasing for us in Chicago and New York) we called for 10 110-volt lamps of 16 c.p. in each case. Ten Sunbeam lamps were divided into two lots of five each, evidently supplied as a sample lot, and were excluded. We could not get others of that make in time to enter the test. There were in all 127 lamps, labelled 110 volts and 16 c.p., of 12 well-known makes.

Current was supplied to the lamps by a 200-light Thomson-Houston dynamo, of the spherical armature type, which proved to be an excellent machine for the purpose. A special device was used to keep the potential at the centre of distribution constant, and it kept the potential difference at the centre at 110 volts, within a limit of three-quarters of a volt either way. For the candle-power measurements a 2-c.p. Methven screen was used, the gas being passed through a Methven carbureter containing pentane. Its constant was checked by standard candles. Three 32-c.p. Edison lamps were used as working standards.

Before the duration test began, the mean horizontal candle-power of each lamp was determined in the usual way, and the ratio of this mean to the candle-power found when the plane of the ends of the filament was perpendicular to the photometer bar was found, and used as the distribution factor. All results are expressed in terms of mean horizontal candle-power. The duration test was begun on March 17th, and it was necessary to run night and day, Sundays excepted, until the night of May 14th to complete 1,200 hours. The run began with 77 lamps on the rack. The remaining 50 lamps were received later, and placed on the rack with the others 187 hours after the start.

The object we had in view in undertaking the test was to determine the character of the incandescent lamp as a commercial product, not as a scientific instrument. The number of lamps of each make taken was, of course, too small to base a fair judgment on as to the absolute or relative merit of the lamps generally sold by the makers. For that purpose some hundreds of lamps of each make, taken from different lots, would have to be tested, which it was of course impossible for us to do. For this reason we have considered it unfair to the several makers concerned to give their names in connection with the results on their lamps, but have instead designated each make by a letter, and each lamp by a number. We believe, however, that the average of the results of all makes may be taken to represent fairly well the character of the average commercial lamp.

The results of the test are given in the tables on following page, the values given being in each case the average for a given make of lamp. Table I. gives in the second column the average value of the distribution factors found for the 10 lamps of make "A," and the average value of the mean horizontal candle powers for those lamps at intervals after the beginning of the duration test, expressed in hours by numbers in the first column. The third column gives corresponding values for the lamps of make "B," and so on. Table I. includes the lamps started March 17th. Table II. contains similar data for the lamps started 187 hours later.

Table III. gives the mean percentage of original candle power for each make at times given in the first column.

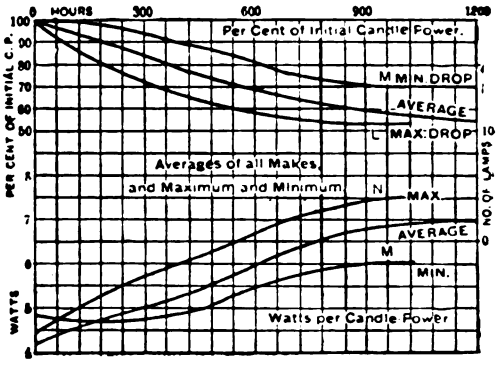
Table IV. gives the average watts per mean horizontal candle power for each make, at times given in the first column.

Thirty-one lamps in all were broken, distributed as follows: All of the C's (10), 2 D's, 8 E's, 2 K's, 4 L's, 1 M and 2 N's. All the lamps of A, B, F, G and O makes survived, the O's for 1,013 hours, the others for 1,200. The average life of the C's was 336 hours.

The plate below gives two sets of curves. One set gives the curve of general average of percentage of initial candle power with respect to time, derived from the averages of the several makes, and beside it the curve of the make which showed highest percentage throughout, marked min. drop, make M, and also the curve showing lowest percentage, marked max. drop, make L. The other set shows the general average of watts per candle power, and also the curves of the two makes showing the maximum (make N) and minimum (make M).

Examining the results first for candle-power, we find the value 14·5 as the average of all the lamps tested at the time the current was first turned on them. Of the 13 separate lots, six only show an initial candle power of 16 candles (neglecting tenths), though one make which started at below 15 rises above 16 within the first 100 hours. The lowest initial candle-power is found for make M. Makes G, K and O start at 17 candles, the highest figure reached at the start.

Looking at the curve which gives the average percentage of initial candle-power, we find that the lamps on the average grow dim at a steady rate, falling off to 90 per cent. in about 200 hours, to 68 per cent. in 600 hours, and end at 1,200 hours with a little less than 55 per cent. Deferring the consideration of the C lamps, the M lamps sustain their power best, losing only about 6 per cent. in the first 300 hours, and ending a little under 70 per cent. of their initial candle-power. The L lamps drop rapidly on the start, losing 30 per cent. in the first 300 hours and ending at 54 per cent. The E's and the O's drop to 47 per cent. at the close, but sustain themselves better than the L's in the earlier part of the run.



With respect to efficiency, using the term in its ordinary signification, as measured by watts per candle-power (though in this sense the reciprocal is the proper measure). The curves show an average initial value of 4·2, rising to 5·0 at 300 hours, 5·9 at 600 hours, 6·8 at 900 hours, and 7·0 at the end. The M lamps again have the best place, starting high but ending low, at six watts per candle-power.

But what shall we say of the results as bearing on the question of the life of the lamp? The answer depends on what we shall define the life of a lamp to be. Is a lamp alive as long as current will go through it? Adopting this view, our test shows 96 out of 127 lamps decidedly alive at the end of an average of 1,120, and the levelling of the average curves promises a considerable extension of their existence; 31 only have proved their mortality, and several of them lived to a good old age. The C's, poor things, all died young. If we set the time of decease at the time when the lamp gives 50 per cent. of its initial candle-power, as some claim, the lamps tested have passed 1,000 hours on the average, and certain makes have passed 1,200. If life be defined still with reference to percentage of initial candle-power, but the limit be placed at 75 per cent., some individuals are still alive, but on the average, all died at 450 hours; 80 per cent. as limit cuts them off at 330 hours, and 90 per cent. at 180.

But there is yet another way of defining the life of a lamp. The one who ultimately pays for the lamp is the one whose premises are lighted by it, and the thing he is supposed to pay for is light. For him, the lamp is dead when it ceases to give a certain candle-power, without reference to what its candle-power was when it was new. His premises, let us suppose, are properly lighted by a

* Abstract of a Paper read at the general meeting of the American Institute of Electrical Engineers, Chicago, June 6, 7, and 8, 1892.

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certain number of new lamps, which actually give 16 c.p. But when their light drops to 14 (12½ per cent.), he is no longer satisfied (and he ought not to be). For him the average lamp lasts about 240 hours. But if he is at liberty to choose the make of lamp, without reference to its efficiency, he will probably call for lamps of the G make, and get 400 hours' service from them. If, however, he can induce the maker of the M lamp to make a lamp giving 16 c.p. when new, and having the same characteristics as those we tested, he will choose M's, and get 500 hours' life. And that is the best that can be done for him, so far as this test shows. He would not have B's, L's, or M's, as at present made at all, because they do not give 14 c.p. when new, and if the station manager puts in F's or N's he would order them out in less than a week. The state of things revealed by this test, as to the actual candle-power of new lamps, is certainly not what it ought to be.

At the conclusion of the life test we dismounted all the lamps and placed them on a large table covered with clean drawing paper and uniformly lighted. The several lots were carefully examined with reference to blackening, the lot which was blackened the most being graded 100, and the other lots graded as closely as we could judge by comparison with the blackest lot and with one another. The grades are as follows: 10, 12½, 25, 28, 30, 32, 35, 42, 45, 50, 75, and 100 per cent. of the blackening of the blackest lot. When the sorting and grading were satisfactorily completed, and the letters on the lamp bases examined, it was remarked that *the two lots which were least blackened were of the makes which are advertised as exhausted by mechanical pumps.* That they should both be so much alike in blackening, and both only one-half as much blackened as the least blackened of the mercurially exhausted lamps, is, to say the least, worthy of notice. It is, of course, not established that the observed freedom from blackening is due to the absence of mercury vapour in the lamps, as the makers claim, but if investigation should establish the claim the mercury pump will probably become once more a laboratory instrument.

So far as the lamps tested may be considered to fairly represent it, we draw from the test the following conclusions concerning the average 16 c.p., 110 volt, incandescent lamp:—

1. The mean horizontal candle power of the lamp as defined is only 14·5 when new instead of 16 as labelled.

2. The candle-power of the lamp diminishes at a fairly uniform rate as it is burned, the rate of decrease being roughly 10 per cent. of the initial candle-power for each 200 hours burned.

3. The lamp makers' claim that the lamp will burn for 600 hours before breaking, is more than established, 96 out of 127 lamps being unbroken at the end of over 1,100 hours.

4. Defining the life of a lamp to be the number of hours it will burn before it will fall from 16 c.p. to 14, we find the life of lamps in all respects like those tested, but so made as to give an initial candle-power of 16, is 240 hours.

5. The initial efficiency of the lamp is 4·2 watts per candle power. At 600 hours it is 5·9 watts, and 1,200 hours 7 watts. The average efficiency during the first 600 hours is 5·04 watts.

6. There is considerable difference in the rating of lamps by different makers, who nominally furnish the same article, the average initial candle-powers of the several lots ranging from 12·5 to 17·0. There is also considerable difference in the uniformity of the product of different makers.

The above conclusions properly complete this Paper, so far as the purpose of which the test was undertaken is concerned. Some interesting points in the relative performances of different lamps may perhaps be alluded to in addition, since they cannot affect the makers.

The most interesting result arises from a comparision of the lamps L and M. The L's have the highest initial efficiency (3·8), and the M's the lowest (4·8), excluding, of course, the C's, which cannot be classed with good lamps, but after 250 hours' burning the efficiencies are the same (4·75). At the start the L's are furnishing light at the least cost, but after 250 hours the M's have the advantage in this respect. If we suppose both makes to be used for 700 hours, the average efficiency is the same for both. But at this time the M's are giving 75 per cent. of their initial candle-power, while the L's are giving only 55 per cent. For the consumer the M lamp is the better of the two, since the lighting of premises will be more uniform throughout the 700 hours of use supposed, and the cost of current for a given aggregate of candle-power hours is no greater than with the L's. If the time of use of the lamps be, say, 400 hours, the choice is not so evident, and will depend on whether the slight difference in cost (watt hours) is of greater or less importance than constancy of candle-power of the lamps.

Table I.

Lamp.	A.	B.	C.	D.	E.	F.	G.	K.
Distribution factor.	1·05	1·07	1·01	1·11	0·989	1·01	1·01	1·02
Hours from start.	C.P.	C.P.	C.P.	C.P.	C.P.	C.P.	C.P.	C.P.
0	16·0	13·1	14·1	16·1	15·9	14·2	17·1	17·0
93	15·0	12·4	14·8	16·1	13·7	12·1	15·9	16·1
233	13·65	12·4	14·9	16·0	13·1	12·9	16·4	16·5
324	12·2	11·0	14·8	13·9	10·9	10·8	14·5	13·9
392	11·7	10·5	14·0	13·2	10·5	10·4	13·6	13·4
441	11·3	10·2	14·2	12·7	10·1	10·2	13·3	13·1
537	10·9	9·9	13·6	12·3	9·9	10·0	13·0	13·0
637	10·7	10·1	13·0	11·9	9·5	10·1	12·4	12·4
785	9·4	9·2	12·6	10·5	9·1	9·1	11·4	10·9
833	9·1	8·6	All out	10·1	8·5	8·5	10·9	10·3
883	8·6	8·2	...	9·3	7·7	8·0	10·4	9·8
972	8·6	8·3	...	9·2	7·6	8·0	10·4	10·0
1,105	8·6	8·2	...	9·2	7·4	8·0	10·3	9·5
1,190	8·2	8·0	...	9·0	7·5	8·0	10·4	9·6

Table II.

Lamp.	L.	M.	N.	O.	P.
Distribution factor.	1·10	1·00	·911	1·00	1·02
Hours from start.	C.P.	C.P.	C.P.	C.P.	C.P.
0	13·2	12·5	14·1	17·9	11·6
71	12·6	12·5	13·5	...	...
137	10·7	12·6	11·7	16·4	15·9
205	10·1	11·9	11·0	14·8	13·6
254	9·7	11·6	10·4	14·0	13·0
319	9·3	11·8	10·1	13·3	12·3
450	8·9	11·5	9·4	11·6	11·6
598	7·8	10·6	9·3	10·8	9·7
646	7·6	9·6	8·2	9·6	9·2
696	7·1	9·3	7·9	9·0	8·4
785	7·1	9·4	7·8	9·0	8·7
837	6·8	8·7	7·5	8·3	8·5
1,003	7·1	8·8	7·4	8·0	8·4

Table III.

Lamp.	A.	B.	C.	D.	E.	F.	G.	K.	L.	M.	N.	O.	P.	Average.
Hours.	%	%	%	%	%	%	%	%	%	%	%	%	%	%
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
100	93	94	106	101	92	93	95	93	87	100	87	95	107	95·6
200	86	89	109	99	84	86	90	87	78	98	79	87	97	90
300	79	83	106	93	77	81	86	83	72	94	72	80	86	84
400	74	80	102	82	72	77	81	78	67	90	67	72	78	78·4
500	69	73	98	75	66	70	77	74	63	86	63	66	71	73
600	64	70	94	70	61	66	73	70	59	80	60	60	65	68·6
700	61	67	91	66	57	62	70	67	55	75	56	55	60	64·7
800	58	64	90	63	53	59	66	63	54	73	55	51	58	62
900	55	63	All out	60	51	57	63	59	53	70	53	49	56	57·4
1,000	54	62	...	58	49	56	62	58	54	70	52	47	57	56·6
1,100	52	61	...	57	47	56	61	57	...	...	...	...	...	55·8
1,200	51	61	..	56	47	56	61	57	...	..	...	..	...	55·4

Table IV.

—	Watt per mean horizontal candle power.													
	A.	B.	C.	D.	E.	F.	G.	K.	L.	M.	N.	O.	P.	Average.
Hrs.														
0	3·9	4·4	5·4	4·3	4·1	4·1	4·2	3·9	3·8	4·8	4·4	3·9	4·0	4·2
100	4·3	4·8	5·6	4·5	4·4	4·3	4·6	4·3	4·2	4·7	4·9	4·5	3·8	4·5
200	4·6	5·1	5·6	4·5	4·7	4·6	4·9	4·6	4·6	4·7	5·3	4·9	4·1	4·8
300	4·9	5·4	5·7	4·8	5·0	4·9	5·0	4·8	4·9	4·8	5·7	5·2	4·5	5·0
400	5·2	5·6	5·9	5·3	5·4	5·1	5·3	5·0	5·2	4·9	6·1	5·4	4·9	5·3
500	5·5	6·1	6·2	5·8	5·7	5·5	5·6	5·2	5·5	5·1	6·3	5·8	5·2	5·6
600	5·8	6·4	6·4	6·1	6·1	5·8	5·7	5·4	5·8	5·5	6·7	6·3	5·6	5·9
700	6·1	6·7	6·6	6·4	6·5	6·1	6·0	5·6	6·1	5·8	7·0	6·9	6·1	6·3
800	6·4	6·9	6·7	6·7	7·0	6·4	6·3	5·9	6·3	5·9	7·2	7·4	6·2	6·6
900	6·7	7·0	...	7·0	7·2	6·6	6·6	6·2	6·4	6·1	7·4	7·7	6·3	6·8
1,000	6·8	7·1	...	7·2	7·4	6·8	6·7	6·4	6·2	6·1	7·5	7·9	6·2	6·8
1,100	7·0	7·2	...	7·3	7·6	6·7	6·8	6·5	...	...	...	...	...	7·0
1,200	7·1	7·2	...	7·4	7·6	6·7	6·7	6·5	...	...	...	...	...	7·0

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COMPETITION.

Competition is regarded as a form of industrial suicide by one man and as the very salt of commercial enterprise by another. It must be admitted that, when a large proportion of the exertions of a firm or of an individual is expended in opposing, frustrating, or wastefully supplementing the work of another, there is waste indeed, and waste not only of time and money, but of good work which might better have been spent in some other direction. But while commerce and manufactures could doubtless continue to meet existing demands without competition, all real progress is essentially connected with this principle; and any interference with it will not only deaden the originality of the producer, but must limit the choice of the consumer. Most contractors who have tendered for shiplighting sets for the Admiralty have complained of the cutting of prices; but perhaps nothing else has done more to develop and to improve the continuous-current dynamo in this country than the stringent conditions as to weight, size, and heating which have been laid down in the Admiralty specifications. Before there was any such competition, the Admiralty accepted and used those extraordinary and elephantine machines which were called B Grammes; and it is difficult to conceive by what else than the spirit of

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trade emulation improvements could have been achieved. Neither the maker nor the buyer has any idea of the possibilities which are within easy reach unless this powerful incentive to progress is felt. There has been much less competition in the high-speed engines used for shiplighting. The Willans has been most successful, but the Admiralty engineers have been opposed to the closed sides; and although engines, of which one was shown at the Crystal Palace, have been built to meet this doubtfully founded objection, they have taken the matter in their own hands and have built an engine for themselves at Portsmouth Dockyard. It is to be hoped that this will be used as a pattern for the guidance of other makers, rather than as a precedent for the construction of engines for shiplighting by dockyard labour, for the chance of further improvement would then be remote. We probably should not yet have had sixpenny telegrams in this century had it not been for very shame that other nations were leaving us behind; and but for the same incentive we should still have been obliged to send letters for India and China in large quantities to France, whence they could be posted for twopence halfpenny instead of fivepence; and even now the only economical way of posting samples to English towns is to send them first to Belgium. Without the prospect of wholesome competition it would be too much to expect our glow lamps to be even what they are, and we shall not be surprised to find some marked improvements before two or three years have elapsed.

Competition conduces perhaps to development in quality with less disagreeable results than where price is principally affected. In the former case, it is true that the producer who is only second best in the race is compelled to modify his work, perhaps to replace his plant, by improved machinery, having by over confidence found himself encumbered with obsolete stock. Where there is little choice in quality, the fight for price seems sometimes to support the pessimistic idea of industrial suicide to which we have alluded. When prices are cut so much that capital cannot earn four or five per cent., it is quite time that that better part of valour, discretion, should be used; when dividends are declared in shillings per share, it often means that too much capital has been attracted, or, at least, that it has been improperly spent.

COMMUTATORS.—III.

BY F. M. WEYMOUTH.

(*Continued from page 309.*)

Now as to the washers and heads, it will be noted that in Fig. 5 (see p. 309 of our last issue) there is one of the former at each end, on account of the flat head. A point, however, to which attention may be drawn is the angle with the axis under the head and washer, as at *m* and *n* Fig. 3 (see p. 309 of our last issue), assumed in different designs. This, as will be seen further in subsequent sketches, varies from about 60° and 50°, to 45°, 30° and even less. A great difference thus exists. The principal point to be attained, however, beyond holding the segments securely against the centrifugal force tending to make them fly off, is to hold them so firmly together, considering the large number of parts forming the whole, that they shall not easily be put out of truth after leaving the lathe, by any accidental blow or jar. With the larger angle, the best effect of course is to hold the segments tightly between the washer and head; while the smaller angles have a best effect in holding the segments in toward the axis. It has to be considered, however, that insulating materials have not the same density and solidity as metals. They, moreover, vary in nature, and, as has already been pointed out, fibre is apt to absorb moisture and swell thereby, and to shrink again when dry and hot. Now this shrinkage would naturally have more effect in loosening the bars diametrically with the large angles than the small. Thus a small angle with the axis might seem the best with fibre. But a substance less liable to shrink, such as mica, may be preferable for large angles. Conversely also, in consideration of its laminæ being in planes normal to the axis of the shaft, a large angle would be better for the mica, when so used. With a small angle and assuming the possibility of there being any *give* in the insulation between the bars, and assuming further that these are tightly fitted on the cylindrical body of the sleeve, with hard insulation between, then on the nut being tightened up, and the slope of the washer having its best effect diametrically inwards, there would be a tendency for the ends of the bars within the washer to become jambed against the sleeve, the slope of the washer in a manner acting as a wedge. The result of this would thus be, that the segments dragging on the sleeve would not be driven home so tight under the head as under the washer. In Fig. 5, where the angle is very small indeed, any possibility of this eventuality is met by the fact that the washers at each end lie flat against the nut and head respectively, and also against the bar ends; and thus the bars are driven directly by the nut. There does not seem much allowance here, however, for any give of the insulation enclosed between the washer and the projecting heels or snugs of the segments. A practical point is to allow a thickness of sleeve where the nut rides for a sufficiently large thread; and a length parallel with the axis, such that the nut may not be too thin: thus tight screwing up may be effected without the thread stripping, or the nut bursting, which is of course a matter of primary importance in securing the solidity of the whole mass. This nut, it should be mentioned, requires to be locked to prevent possible slacking back. One method is to put radial screws through it, generally three, with their points taking into the sleeve. Another method is to put one or more screws parallel with the shaft through the nut, with their points taking into the washer, as shown in Fig. 13.

But now we may turn our attention to commutators of the second kind in our classification. We find these exemplified in Figs. 7 to 10. Of these, Fig. 7 is a Kennedy design; Fig. 8 an example from a "Westminster" dynamo by Messrs. Latimer Clark, Muirhead, and Co.; Fig. 9 a Gülcher; and Fig. 10 an early type of Kapp commutator. Here, as was intimated, a special object has been to secure a short total length in proportion to the length of brush contact surface. The difference between these and the first four is at once apparent, in that they are undercut at the ends, and the washer and mushroom head more or less let into the ends of the segments. This is especially the case with Figs. 7 and 8; while with the former in particular the total length scarcely exceeds that of the segments. A further difference, however, will be seen, in that while the segments of the first four were all bedded on the sleeve with insulation between, in these latter there is no insulating material here, an air space between being left instead. Moreover, whereas the washers and heads of the former had only one slope, tending to force the segments inwards, in these latter, excluding Fig. 8, there are two slopes. Thus the effect of tightening the nut is to maintain the segments at a constant diameter or pitch, instead of only forcing them inwards. This forms an essential difference in construction. The angles of the reverse slopes are 45° with the axis of the shaft. Now in Fig. 8 we find this peculiarity that air spaces are left, lettered *l l*, between the inner side of the undercut, and the outer periphery of the insulation; while at the same time there is no bedding on the sleeve, and the washer and head have only one slope. Thus the bars are all simply pressed inwards by tightening the nut, and held together like the voussoirs of a circular arch or culvert; the case would be analogous in Figs. 3 to 6 were the interior insulation round the sleeve omitted or be but loosely fitted or packed in. If, however, returning to Fig. 8, the spaces *l l* were filled up solid, then the segments here also would be maintained at one set diameter or pitch, as in the case of Figs. 7, 9, and 10. Assuming, however, the single slope, without there being any direct support for the bars radially from the

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centre, then, especially when the commutator is divided into a large number of parts, the taper of each segment on its cross section is so slight that an accidental blow on the outside, on any one or two of them, might drive them in, in spite of the tightness of the nut; thus the whole would be put out of truth, necessitating a return to the lathe. Hence a direct support both inwards and outwards would appear preferable, either by means of the single slope under the head and washer, and bedding on the sleeve, or else by double slopes on washer and head, as in Figs. 7, 9, and 10.

Now in these four designs, Figs. 7 and 8 especially, it will be seen that the brushes cannot wear right through, as they were open to do in Figs. 3 to 6, for they would reach the washer and insulating ring before doing so. They all have a clear shoulder, as at *i*, Fig. 4. It might appear in reference to Figs. 7 and 8 that on much wear taking place the sections of the segments at *r* would become so reduced as to choke the current flowing to and from the lug. But as so little wear is allowed at all, renewals would be needed before much trouble in this direction could arise, at least, in the case of Fig. 7. Excessive wear may, of course, lead to difficulties here, as elsewhere. In the other designs the undercut is not nearly so great. It may be observed that there was a slight undercut at the lug end in Fig. 6.

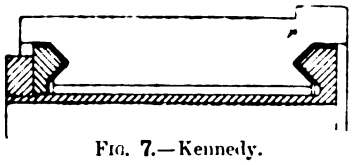

Fig. 7.—Kennedy.

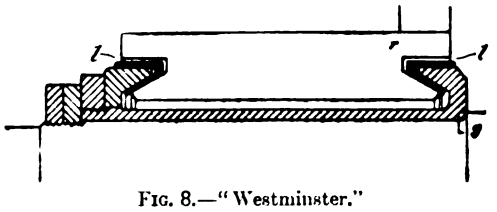

Fig. 8.—"Westminster."

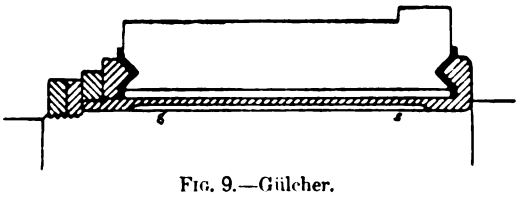

Fig. 9.—Gülcher.

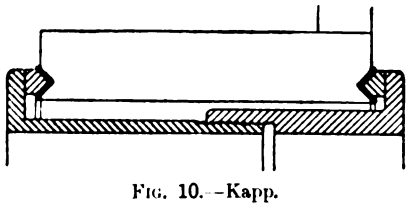

Fig. 10.—Kapp.

Regarding the matter now, however, from the point of view of prime cost, we find these latter four examples compare favourably with the former. Thus a slight gain accrues at once from the shorter sleeves. But from the fact that there is no insulation between the bars and the sleeve, and provided the air space thus left is not less than, say, $\frac{3}{16}$in., there is no necessity either to bore the interior of the segments or to turn the outer cylindrical surface of the sleeve; and so machining is saved. In Fig. 9 a further saving in this same direction is effected by chambering the interior cylindrical surface, lettered *s s*, thus leaving only the ends to bore smooth to fit the shaft, while the chambered portion need have only a roughing cut taken off it, if any. Moreover, as the length of the segments themselves in the latter four does not exceed what is required for the brushes and lugs, whereas in all the other designs we illustrate there are projections at both ends beyond these limits, metal is saved in this respect. Economy is also effected, of course, in insulation.

Now, a distinctive feature in Fig. 10 is that nuts are eschewed, and two sleeves are used, the one screwing into the other, as shown. As in Fig. 5, however, it has two washers, one at each end, and both from the same pattern. We may note that these have a characteristic which they hold in common with the washers in Figs. 5 and 6. For they simply ride on the projecting heels of the segments, and have no efficacy themselves in maintaining the truth of the commutator beyond forcing the segments on to the interior insulation. In the other designs before us the washers are bored to fit the sleeve, and so are centred on it; and they are thus the better adapted to assist in maintaining the truth of the commutator. A further distinctive feature in Fig. 10 is that they are not centred on anything, and entire dependence for maintenance of truth is apparently placed on the friction of the grip between the sleeve heads.

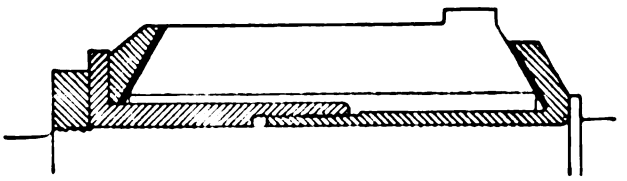

Fig. 11.—Kapp.

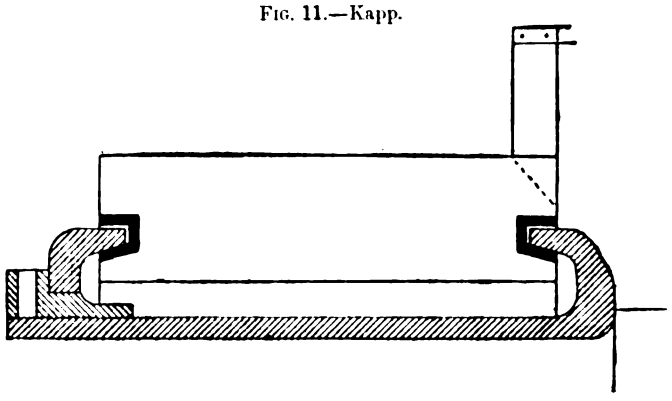

Fig. 11A.—Kapp.

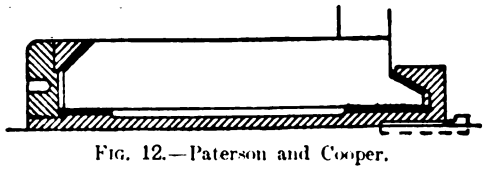

Fig. 12.—Paterson and Cooper.

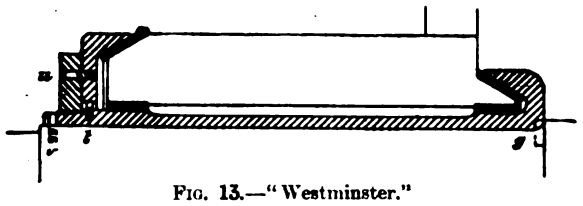

Fig. 13.—"Westminster."

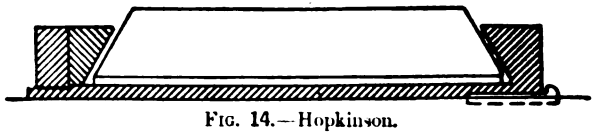

Fig. 14.—Hopkinson.

An advantage, however, in connection with these latter four designs is that for larger diameters of commutator, while assuming the same diameter of shaft, it is only necessary to increase the diameters of the washers and nuts, simply leaving a larger air space between the segments and the bush. For very large diameters the bush may be double, being composed of an inner cylinder riding on the shaft, and an outer cylinder carrying the segments, united by radial ribs to the inner one. By this arrangement passage for ventilation is afforded by the space between the cylinders.

We now come to four more designs, Figs. 11 to 14. Of these the first two, it should be stated, we borrow from Prof. Silvanus P. Thompson's "Dynamo Electric Machinery." Fig. 11 is another design by Mr. Gisbert Kapp, and Fig. 12 one by Messrs. Paterson and Cooper. Fig. 13 is another "Westminster" design; and Fig. 14 is a design adopted by Dr. Hopkinson, though with this latter we are not able to show any insulation. Fig. 11 will be seen to be similar to Fig. 10 in having a double sleeve: otherwise it is totally

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unlike. It is, however, similar to Fig. 14 in simplicity of end slope, and in having very large angles. Fig. 11A represents Mr. Kapp's latest form of commutator, which we borrow from the very fine collection of plates at the end of the fourth edition of Prof. Thompson's book above referred to. It will be observed that the double sleeves are abolished, only a very fragmentary idea of a second sleeve being represented by a prolongation of the nut. Comparing with Fig. 8, it will be observed that the gaps there lettered *l* are here inside the insulating cones, instead of outside. But this apparently small transposition of the gap is not without effect. It will be seen that it makes all the difference between the circular arch principle of support for the segments, already alluded to, and a solid central bedding. For with the gap inside the insulation, as shown in Fig. 11A, the segments are directly supported by the cones at either end, and so cannot fall inwards toward the centre, and are, in fact, held at a certain rigid pitch or diameter, in the same manner as with Figs. 7 and 9. The horizontal and vertical gap, combined with the small angle, at the same time permits of the flanges of the mushroom head and washer being forced up so as to give the cones a thoroughly tight grip centrally; though the lasting efficacy of this may depend on the insulating material used, in conjunction with atmospheric and other external conditions. There is no insulating substance between the segments and the sleeve; and the effect of the very small angle under the mushroom-shaped nut and head being to draw the segments hard in towards the axis, there is nothing approaching a drag on the sleeve tending to prevent the segment ends going home equally tight under the head and under the nut. The washer rides on a shoulder of the nut, and so is centred on it. More economy of metal is attained in the head than in some other designs, and the outer slope and rounded angles of this assist the passage of air from within the armature. It may be noted further how that, in accordance with previous remarks, owing to the adoption of an air space for insulation between the segments and the sleeve, and to the supporting of the segments at the ends only, a large diameter may be, and is, reached by simply increasing the diameter of the washer and head. The sleeve, nut, and washer are of gunmetal.

Figs. 12 and 13 will be seen to have similar segments, and both differ from the remainder in that they have insulation under the ends of the segments only. They thus effect a compromise in this respect between the first four designs and the second four we have illustrated. Bedding on the sleeve is secured without the expense of carrying this the whole length of the segments, and so saving in both machinery and insulation is effected. In Fig. 12 a small washer of triangular section is used, which rides, however, on a shoulder on the nut, and so is centred. In Fig. 13 the washer rides on the sleeve, and is prevented from turning by a pin let into the sleeve, as shown at *t*. The object of this is two-fold, inasmuch as it prevents any possibility of slewing the segments on tightening the nut; and also it gives security for locking the nut by means of the screw *u* put through both parallel with the shaft as shown. Another simple method for securing the same ends is to cast a snug on the inner periphery of the washer, in such a manner as not to interfere with its being turned in the lathe, which shall engage between snugs or in a slot in the sleeve. For the evil of slewing the segments, caused by the washer going round with the nut (when not prevented), and taking the ends of the segments with it, is not an imaginary one; though many makers rely on the tight clamping of all the parts together during the process of tightening up the nut, for its prevention. A further distinctive feature about Fig. 13 is that it is put on the shaft without being held there by a nut or nuts at the end. A sufficiently stout steel screw is put in at the end of the sleeve projecting beyond the nut, as shown at *v*, experience, so far as we are aware, justifying this as quite enough. For as there is no conceivable force, at least such as could be anticipated, apart from mere vibration, with a tendency to separate the commutator from the armature, there seems no reason why the simple screw should not be sufficient. This method is, however, not peculiar to the one type we illustrate.

(To be concluded.)

RECENT DEVELOPMENTS IN ELECTRIC ARC WELDING.

BY P. I. UNWIN.

In the arc process of electric welding under the Benardos patents three separate and distinct methods are in daily use. Between these there is a vital difference, and much difficulty and confusion have arisen from the want of distinction between the three. The first method is welding proper, in which the wrought iron or steel to be united is raised only to the welding temperature, and a perfectly fibrous weld is thereby obtained, which is as strong as the original material, and may be stronger if sufficient work, either hammering or pressure, be put upon the weld. No reinforcement of the weld is used in this case.

The second method is called a "built weld," by which small pieces of metal are melted into the joints and hammered in. The melting, of course, destroys the fibre of the metal, but this is partially restored by the work put upon it. The joint in this case will probably be part fibrous and part crystalline on fracture, but any weakness owing to the percentage of crystalline metal will be largely allowed for, in the additional thickness which this weld possesses. It has been found advisable, after the trial of many materials for reinforcing a built electric weld, to use a special grade of very mild low carbon steel. In the following sketch (Fig. 1) at A and at B may be seen examples of these two methods of welding: A illustrates a built weld, B illustrates a weld proper.

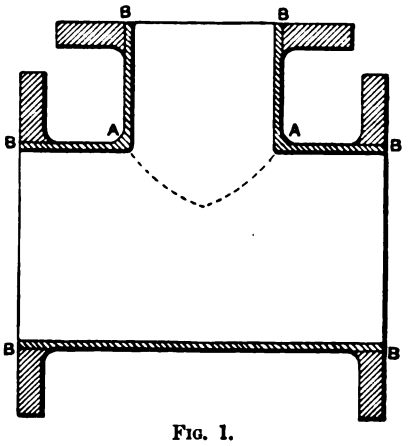

Fig. 1.

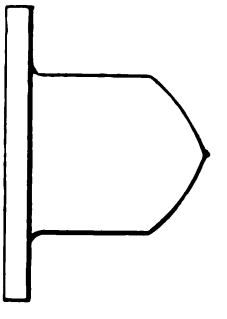

Fig. 2.

Tee Piece for Marine Steam Pipe.

The third method is not at all suitable for the welding of wrought iron and steel. It is used chiefly in repairing *castings*. It consists in fusing pieces of metal into the weld—or defective place in the casting—until the metal is a molten mass locally. In the case of cast steel the hammer may be applied to produce a smooth surface, when the metal has partially cooled; but in the case of cast iron the whole casting must be kept black hot during this process of cooling. In welding wrought iron and steel it is of vital importance that the arc should be maintained at least 2in. long or more, and should be kept continually and rapidly moving over the surface of the metal to be heated.

Let us take for example the case of a steel flanged "tee" for a marine steam-pipe line, say 8in. diameter, having a 6in. flanged outlet. This embodies the first two methods of welding, and also utilises the arc, not for the purpose of uniting, but for separating the metals. A piece of tube, 8in. internal diameter and $\frac{5}{16}$in. thick, is taken, and a circular hole, 6in. diameter, cut by means of the arc. This is effected with a powerful short arc, held stationary, and close to the metal, through which it quickly cuts a groove about $\frac{1}{4}$in. wide; a circular hole about 6$\frac{1}{2}$in. diameter is thus made in the tube. The inner end of the outlet is then shaped by the same method, thus (Fig. 2), and the two are then placed together, and lightly tacked to keep them in position during the welding. Pieces of steel are now welded all round the joint, being fused in place, and then hammered to shape while cooling, forming thus a strong fillet all round the joint.

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The current required for this process is about 150 amperes and 65 volts at the arc. The outlet now being welded, the flanges are next shrunk on, each being about 1in. thick, and 14in. diameter. The operation of welding these flanges comes under the first category of welds, and is most speedily effected by means of two arcs working in parallel on the weld, one within, and the other on the flange, and outside the tube. About 4in. will be heated at a time in this way, using 300 amperes in each arc.

Many people have been surprised by the large area of metal thus heated at one time; but it should be remembered that intense local heating raises the metal beyond the welding temperature, and at best produces merely a soldered joint, the plastic stage, when the metal is weldable, being passed too rapidly for it to be taken advantage of. Having now its three flanges welded on, the tee is tested hydraulically to 800lb. per square inch. It is found that if the test be carried to the destructive limit 1,700lb. per square inch will be sustained before fracture, which will probably take place in the form of a slight crack in the throat of the fitting at A. It will be seen, therefore, that if a fitting is used for steam at a pressure of 170lb., a factor of safety of 10 is thus allowed for, which is amply sufficient, in the opinion of "Lloyd's Shipping Register." Every fitting when complete is carefully annealed, taking 24 hours to cool, thus removing the possibility of any trouble arising from unequal strains caused by local heating. Finally, the flanges are turned all over, back and front, and drilled for the bolt holes.

Marine engineers, who have a large experience of the use of copper pipes and fittings with brazed flanges, will be able to judge whether steel pipes and fittings are not superior to copper, which is now so generally acknowledged to be treacherous at the high pressures of steam in use at the present time.

THE AYRTON-MATHER-D'ARSONVAL GALVANOMETER.

In the Paper on Galvanometers,* by Messrs. Ayrton, Mather, and Sumpner, which was read before the Physical Society on January 17, 1890, it was recommended that the suspended coil of a d'Arsonval galvanometer should be long and narrow, that there should be no stationary iron core, and that the poles of the magnet should be very close together; and on March 21, 1890, in a Paper, by Mr. Mather,† upon the Shape of Movable Coils used in Electrical Measuring Instruments, the subject is more fully dealt with. It was shown in the latter Paper that in ordinary commercial instruments it is important that the period of oscillation should not be inconveniently long, and that the power consumed by the instrument should be as small as possible. Then, since for a constant period the controlling moment at unit angle must be proportional to the moment of inertia of the moving part, the problem resolves itself into finding the shape of the section, such that the total deflecting moment for a given total moment of inertia is a maximum. The most efficient section of the suspended coil was found to consist of two circles, touching one another at the vertical axis of suspension. Another way of treating the problem resolved itself into finding the shape and position of an area having a given moment of inertia about a point in its plane, such that the moment of the area about a coplanar line through the point is a maximum. This gave an identical result. In the Ayrton and Mather-d'Arsonval galvanometer, made by Mr. Paul, and exhibited at a recent meeting of the Physical Society, a narrow coil is enclosed in a silver tube, which serves the double purpose of damping the motion and as a case or mounting for the coil, allowing it to be handled and clamped for travelling, without fear of injury. The mirror is attached to the silver tube by a light three-armed clip, thus avoiding the difficulties of cement. Fig. 1 shows the tube and mirror, full size. Part of the tube is broken away to show the coil, and the connection of the end through an insulating collar. Fig. 2 shows the outer brass tube half-size. The coil tube is hung within it by a flattened phosphor-bronze wire, and the lower connection is made by a spiral of phosphor-bronze. A mirror-box is provided with a sliding glass plate. The clamping arrangement is well devised, and consists of a button sliding in a slotted spring. When the button is at the top of the slot, as shown in Fig. 2, it

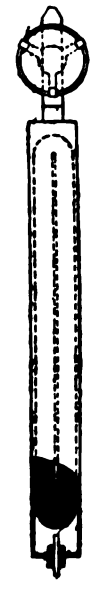

Fig. 1.—Coil Tube and Mirror, full size.

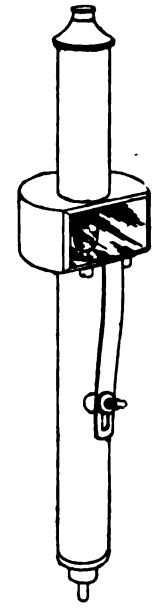

Fig. 2.—Outer Brass Tube, half size.

is opposite a hole in the outer brass tube, and by the pressure of the spring holds the silver tube without putting any longitudinal strain on the suspension. To release the clamp the button is drawn forwards and pushed down in the slot. The outer tube, with its mirror-box and torsion head, is self-contained, and the act of sliding it into its position between the poles of the magnet makes the contacts. These tubes are interchangeable, and several coils of different windings can be kept ready, and slipped in place in a few seconds. The permanent magnets are of circular form

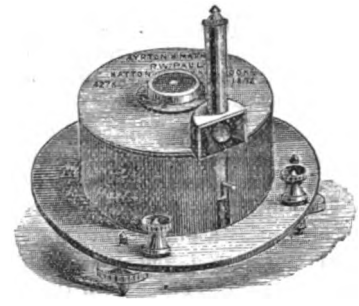

Fig. 3.

(Fig. 3), with a narrow gap between the poles. A circular level and insulated levelling screws are provided. The advantages of portability, dead-beatness, and quick swing are thus combined, without any sacrifice of sensibility.

* *The Electrician*, Vol. XXIV., p. 351. † *Ibid.*, p. 577.

FOREIGN ELECTRIC LIGHTING AT THE CHICAGO EXHIBITION.

The following extract from a report to the Royal Commission, made by the Secretary of the Commission (Sir Henry Wood), on his return from Chicago, will be read with interest:—

Electric Lighting.

I made inquiries as to the arrangements for electric lighting, and ascertained that a small amount both of arc and incandescent lighting is being retained for foreign exhibitors, and that if any English company desired to take this up on the terms which have already been published, they could do so. The main bulk of the electric lighting has been arranged for on a commercial basis with American firms. They have not yet got all

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the power required for running dynamos, and would be glad if English exhibitors could send one or two 500-horse power engines for the purpose. These engines would be placed among the power plant, and the space allotted for the purpose adjacent to the Machinery Hall.

Such engines would have to be delivered free on the cars at Jackson Park. Foundations would be provided and the engines erected by the Executive. The cost of running would also be provided, including wages of engineer, who might, if preferred, be appointed by the exhibitors, but would be under the orders of the Executive. Engines on the same bed plate as dynamo would be quite acceptable. At the close of the Exhibition the engines would be dismantled and placed on the cars.

Special arrangements are to be made for the lighting of the Electricity Building. In this each foreign section can, if it chooses, light up its own space. It is proposed to allow exhibitors to furnish all the lighting plant as exhibits. Steam would be provided free, but no payment would be made. Exhibitors who require current or light, and who do not provide generators, would be charged a low rate. Mr. Hornsby, the Chief of the Electricity Department, could not say what the rate would be, but it would be about cost price. The motors and generators would be placed among the power plant above referred to. Exhibitors will be expected to lay their own cables in the conduits, do own wiring, provide lamps, &c. The generators, cables, &c., might be supplied by different exhibitors.

Exhibitors generating current would be allowed to use as much light as they pleased for themselves. In addition to the light thus supplied, the building will be lighted by arc lamps. For this light there is to be no charge.

THE PROPOSED INTERNATIONAL CONGRESS AT CHICAGO.

We have been favoured with the following copy of the official document emanating from the United States Legation in London announcing the intention to hold a series of International Congresses at Chicago next year, and inviting the cordial co-operation of Her Majesty's Government :—

Legation of the United States,
London, July 16, 1892.

My Lord,

I have the honour to acquaint your Lordship that the Department of State of the United States is in receipt of a letter from Mr. Charles C. Bonney, President of the World's Congress Auxiliary, in which it is stated that, in pursuance of the course indicated in the original announcement of the World's Congress Auxiliary, which was transmitted to your Lordship in my note of February 2, 1891, with the Act of Congress approved April 25, 1890, and the President's invitation of January 14th, 1891, extending to all foreign Governments a cordial invitation to participate in the World's Columbian Exposition, to be held in Chicago in 1893, the work of the World's Congress Auxiliary has been organised to the present date in sixteen Departments, and more than one hundred General Divisions in which Congresses are to be held.

The preliminary organisation of these Congresses are contained in the preliminary publications of the Auxiliary, copies of which are herewith transmitted, and the accompanying printed pamphlets amply disclose the plans, aims, objects, and purposes of the Congresses.

I am, therefore, instructed to say to your Lordship that it is especially desired by my Government that the largest practicable participation of foreign peoples and Governments in the whole series of these important Congresses may be secured, and that it is particularly requested that a convenient number of the most eminent representatives of the various departments of human progress be selected as delegates to attend the respective Congresses, by or under the direction of each of the foreign Governments, in addition to those who will come as the representatives of the leading institutions and societies of the different countries. Such a co-operation on the part of other Governments will, it is confidently believed, tend in the highest degree to promote, strengthen, and extend those fraternal relations and mutual benefits which may now justly be regarded as the supreme object of international intercourse, and as involving a higher civilisation and a broader human progress.

I have, therefore, the honour of communicating this supplementary invitation to Her Majesty's Government; and, in doing so, I venture to call your Lordship's attention to the brief intervening period, and to express the earnest hope that Her Majesty's Government will be disposed to give the necessary co-operation to ensure the adequate participation of Her Majesty's subjects in these interesting Congresses.

I am directed also to say that on receipt of the names of such delegates as may be selected to attend these several Congresses, suitable communications will be promptly forwarded to them.

I have the honour to be, with the highest consideration,
My Lord,
Your most obedient humble servant,
(Signed) R. LINCOLN.

The Most Honourable the Marquis of Salisbury, K.G.

The Schenectady Works.—According to a Dalziel cablegram the Edison works at Schenectady were totally destroyed by fire on Monday morning.

ELECTRICAL STANDARDS.

The following circular, signed by the Secretary, Mr. R. T. Glazebrook, has been issued to the members of the Electrical Standards Committee of the British Association.

A meeting of the Electrical Standards Committee of the British Association will be held at Edinburgh. It is expected that Dr. von Helmholtz, Dr. Lindeck of the Berlin Reichsanstalt and others interested in electrical measurements will be present. A discussion will take place with a view to securing an absolute uniformity in the Standards adopted in England and elsewhere.

The following points will be considered :—

1. The value of the B.A. unit in ohms.
2. The specific resistance of mercury in ohms.
3. Standardising by the electrolysis of silver.
4. The electromotive force of a Clark cell.
5. Report of the Committee for 1892.

It is proposed to take the report of the Committee in the Section on Tuesday, August 9th. The draft prepared by the Secretary is formal; but it is hoped that the discussion in the Committee may lead to some resolutions which will be included in the report. The report of the Electrical Standards Committee of the Board of Trade is printed in the B.A. Report for 1891. Further information as to the values of the units is given in the B.A. Report for 1890. The following summary may be of use.

1. *The Value of the Ohm.*

	Observer.	Date.	Method.	Value of B.A.U. in ohms.	Value of 100 cms. of mercury in B.A.U.	Value of ohm in cms. of mercury.
1	Lord Rayleigh ..	1882	Rotating coil..	·98651	·95412	106·24
2	Lord Rayleigh ..	1883	Lorenz method.....	·98677	—	106·21
3	G. Weidemann..	1884	Rotation thro' 180°	—	—	106·19
4	Mascart	1884	Induced current ...	·98611	·95374	106·33
5	Rowland.....	1887	Mean of several methods.....	·98644	·95349	106·32
6	Kohlrausch	1887	Damping of magnets	·98660	·95338	106·32
7	Glazebrook ..	1882 and 1888	Induced currents..	·98665	·95352	106·29
8	Wuilleumeier...	1890	—	·98686	·95355	106·27
8*	Duncan & Wilkes	1890	Lorenz	·98634	·95341	106·34
8†	Jones	1891	Lorenz	—	—	106·31
			Mean	·98653		
9	Strecker	1885	An absolute determination of resistance was not made. The value ·98656 has been used.	—	·95334	106·32
10	Hutchinson.....	1888		—	·95352	106·30
11	Salvioni	1890		—	·95332	106·33
12	Salvioni	—		—	·95354	106·30
			Mean	.....	·95354	106·28
13	H. F. Weber ...	1884	Induced current ...	Absolute measurements compared with German silver wire coils issued by Siemens or Strecker.		105·37
14	H. F. Weber ...	—	Rotating coil.....			106·16
15	Roiti	1884	Mean effect of induced current ...			105·89
16	Himstedt	1885	—			105·98
17	Dorn	1889	Damping of a magnet			106·24
18	Wild	1883	Damping of a magnet			106·03
19	Lorenz	1885	Lorenz method.....			105·93

The Board of Trade Committee recommended for adoption the values 0·9866 and 106·3.

The specific resistance of mercury in ohms is thus :—

$$0{\cdot}9407 \times 10^{-4}.$$

Also 1 Siemens Unit = 0·9407 ohm
= 0·9535 B.A.U.
1 ohm = 1·01358 B.A.U.

2. *The Electrolysis of Silver.*

The following values have been found for the mass of silver deposited from a solution of silver nitrate in one second by a current of 1 ampere :—

Mascart, *Jour. de Physique*, III. 1884 .....0·0011156
Rayleigh, *Phil. Trans.*, II. 1884 .....0·0011179
Kohlrausch, *Wied. Ann.*, XXVII., 1886 .....0·0011183
T. Gray, *Phil. Mag.*, XXII. 1886 .....about 0·001118
Potier et Pellat, *Jour. de Physique*, IX., 1890 ...0·0011192

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Dr. Schuster has shown, *Proc.* R. S., Vol. L., 1892, that the amount of silver deposited when the voltameter is in a vacuum is about 0·04 per cent. greater than when it is in air.

3. *Clark's Cells.*

The following values have been found for the E.M.F. of a Clark's cell at 15° C. They have been reduced from those given in the original Papers on the supposition that 1 B.A.U. = ·9866 ohm, and that the mass of silver deposited per second per ampere is ·001118 grammes :—

Rayleigh, *Phil. Trans.*, II, 1884	.....	1·4345 volts
Kahle, *Zeitschrift für Instrumentenkünde*, 1892.		1·4341 ,,
Glazebrook and Skinner, *Proc.* R.S., LI., 1892.		1·4342 ,,

A comparison has been made between the standards of the Association and the Berlin standards through a Clark cell and a resistance coil belonging to Dr. Schuster. By the kindness of Dr. von Helmholtz the secretary hopes to have a direct comparison between the two sets of standards completed before the meeting.

LEGAL INTELLIGENCE.

Re the Bankruptcy of Joseph Slater Lewis.

At the Birmingham County Court on Monday the public examination of this bankrupt took place. He is described as of 10, The Avenue, Castle Hill, Ealing Dean, Middlesex, late of the National Telegraph Works, Wainwright-street, Aston. In the course of the examination some peculiar facts were elicited by the counsel for the creditors. It appeared that the bankrupt started in business 20 years ago as a coal merchant, and in 1885 commenced business as an electrical engineer at Helsby without experience. The petitioning creditor is Mr. Archdale, engineer, from whom Lewis purchased a quantity of machinery, which he transferred to a company. With reference to some mutilations of a cash-book the bankrupt could not account for it, and thought he had a right to know who had pulled the leaves out of the book. The Company to whom his business was transferred consisted of a clerk in his employ, a traveller, two foremen, an electrician, and a pupil. He repudiated the suggestion that cheques belonging to the Wirral and Birkenhead Agricultural Society, of which he was the Secretary, had been paid into the electrical company's account. He had offered to set apart a portion of his income from the situation he now held in order to discharge his liabilities. There was no foundation, he said, for the attacks which had been made upon him in reference to his works at Helsby. At the conclusion of the examination, Mr. Sharp, the Official Receiver, asked that the watch and chain the bankrupt was wearing should be handed to him to meet the expense of the official note of the proceedings, as, although the liabilities were returned as £1,613, there were no assets, but the Registrar declined to make the order.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 16, 1892.

The Wright Type-Printing Telegraph.—This machine has just been brought out in this country. The messages are, as your readers will doubtless remember, transmitted by the operation of a keyboard similar in all respects to that of the ordinary type-writers, and they are received upon a sheet of paper eight inches wide, in the form of a type-written page instead of the usual tape. All the letters, numerals, fractions, and other characters necessary to type-writing are provided. In practice a speed of over 40 words per minute on a 200-mile circuit, using the ordinary Morse current, has been reached. It is announced that the United Press has adopted the machine for the distribution of its news throughout New York.

An Edison-Swan Interference Case.—A decision has been rendered by the Commissioner of Patents in the interference between Mr. Edison and Mr. J. W. Swan in regard to the patent for a certain form of incandescent lamp carbon. The decision, which is in favour of Mr. Swan, was made on appeal from the decision of the examiners-in-chief awarding priority to Mr. Edison upon both of the following interference issues :—First, a carbon formed from a straight strip of cardboard, paper, or parchment, and bent to form an arch, hoop, or loop, and carbonized by heat while in a bent condition ; second, a carbon for an electric lamp made of the parchment paper. It was at first thought that this decision of the commissioner in an interference for a patent for which application was made in 1880 might have some effect on the result of the decision in the filament case not yet decided, but which has been before the Court of Appeal for about two months. Inquiry of the companies' attorneys most likely to be concerned indicates, however, that no importance is attached to the question. It is said the process is of no particular value, and is not now used in the commercial manufacture of incandescent lamps. It is said Edison desired to have the satisfaction of seeing the patent interference decided in his behalf, and for this reason his attorneys continued to carry it up on appeal. The patent itself is regarded by the Edison attorneys as of no particular value.

Mr. Cyrus Field.—Among those who attended Mr. Cyrus Field's funeral services were many men who are prominent in the commercial world at the present time as well as others who were the leading financial men at the time of Mr. Field's triumph. Among those present may be mentioned Mr. Chauncey, M. Depew, Mr. Whitelaw Reid, Ex-Governor A. B. Cornell, Mr. Cornelius Vanderbilt, Mr. Henry Villard, Mr. W. E. Dodge, Mr. J. Pierpont Morgan, and Col. R. G. Ingersoll. A telegram of sympathy was received by the family from Sir James Anderson, the commander of the "Great Eastern" at the time the Atlantic cable was laid.

Storage Battery-Traction in New York.—The Second Avenue Railroad Company now operating its system by horses has made application to the State Board of Railroad Commissioners for permission to change its motive power from horses to storage batteries, and the hearing of this application is now going on in this city. The counsel for the railroad company stated at the opening of the hearing that if permission were granted a trial would be made of the new system on one of the company's lines running to the Harlem River at the north end of Manhattan Island. He stated that the total valuation of property along the line was $24,000,000, and that the consent of more than half the property owners had been obtained. It is understood that the system the company intends to try is the Waddell-Entz ; and although this was not mentioned at the hearing the characteristic features of the proposed system which were mentioned seem to indicate that this is the one contemplated. There was no opposition to the granting of the Company's petition, and the Board announced that its decision would be given later. In this connection it may be of interest to note that the King's County Railroad, an elevated structure in Brooklyn, N.Y., talks of making similar experiments. It is said that the matter has been carefully considered by the Board of Directors of the Company, and that they are strongly inclined to give the electrical method of propulsion a thorough trial.

CORRESPONDENCE.

THE DIMENSIONS OF PHYSICAL QUANTITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : I do not propose to anticipate in your columns the discussion on Mr. Williams' Paper, but in the interests of that discussion one or two of "W. M. M.'s" points call for remark.

In the first place I hope that we may avoid a barren debate on the utility of mathematics.

In the next place I cannot understand how those who believe that $[\mu]$ and $[K]$ are concrete quantities, and who also believe that the dimensions of a co-efficient of self-induction are expressed by either of the equivalent formulæ $[L\mu]$ or $[L^{-1}T^2K^{-1}]$ can be accused of holding as a body the diametrically opposite view that self-induction "*is* a length." I can only say for myself that I have always regarded the use of the dimensional expression $[L\mu]$ as a direct denial of the statement that a co-efficient of self-induction is necessarily a length.

On another point it would be well for "W. M. M." to express himself more clearly. He asserts that [L], [M] and [T] are ratios.

Fourier (who first introduced the idea of dimensions) states that "the terms of one and the same equation could not be

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compared if they had not the *same exponent* of *dimensions*" ("Analytical Theory of Heat." Trans. by A. Freeman, p. 128). Hence, to take a simple example, the equation

$$t[\mathrm{T}] = l[\mathrm{L}]$$

in which t and l are abstract numerical quantities, is false, even if the two sides are numerically identical. Will "W. M. M." explain why it is so, if it is merely the analogue of some such expression as

$$2 \times \frac{1}{5} = 3 \times \frac{2}{15},$$

in which all the symbols are abstract and the vulgar fractions correspond to the *ratios* [T] and [L] ?—Yours, &c.,

July 22nd, 1892. ARTHUR W. RÜCKER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Since you have been good enough to forward me Prof. Rücker's letter, perhaps you will allow me to consider it point by point before turning to the earlier letter by "E. M. C." and the criticisms with which you have favoured me.

Firstly, I must disclaim any intention of forestalling the discussion at the Physical Society. My Paper deals with a question antecedent to that of Mr. Williams, and the two debates could only clash should I convert the whole society to my views, which I am not sanguine enough to anticipate. I even resisted the temptation to discuss Mr. Williams' singular reasons for preferring the interpretation he adopts.

Secondly, I deprecate equally with Prof. Rücker a discussion on the utility of mathematics; and strongly suspect that in such a discussion we should be found on the same side.

I must acquit Prof. Rücker of holding the coefficient of self-induction is a length, and admit the force of his position that the view is inconsistent with holding [μ] to be a concrete quantity. But when I wrote I was not thinking only of this latest development of the school, but of all who regard the dimensional formulæ as—to quote Mr. Williams—"representing the *physical identities* of the various quantities . . . . just as the formula of a chemical compound indicates its composition and chemical identity." The quotation "but it *is* a length" is taken from a report of a sectional meeting of the British Association last year, as published in *The Electrician*, Vol. XXVII., p. 504. It was uttered by a prominent exponent of these views, who also regards Prof. Rücker's development of them with favour; and it is for him, not for me, to reconcile the contradiction. I am grateful to Prof. Rücker for this practical exemplification of the rather extreme statement, "What we get out changes from day to day"—a rhetorical phrase which I only allowed to stand because its exaggeration was too palpable to be unfair.

If I omitted to be as explicit as Prof. Rücker seems to desire, it was because I was writing an article, not a treatise, on Dimensions; and I assumed that both sides of the question would be tolerably familiar to your readers. But the question Prof. Rücker puts to me is easily answered. $t[\mathrm{T}] = l[\mathrm{L}]$ is not analogous to $2 \times \frac{1}{5} = 3 \times \frac{2}{15}$; for though [T] and [L] are ratios, they are not constants, they are independent variables, and the true analogue would be $2x = 2y$, where x and y are numerical quantities, but variable at will. I write $2y$ not $3y$, for any relation which is true when the dimensions are introduced is true also without them.

That one physical quantity varies conjointly as certain other physical quantities is a result of observation and experiment. If we wish to turn this variation into an equation between the measures of the various quantities *some* relation between the units of measurement must be assumed. The assumptions are usually made in such a way that the equation is true whatever fundamental units we start with. So we get a ready test of the soundness of any equation. Change the units how you will, subject to these rules, the equation remains true; if it can be made false, there is something wrong.

From the obvious analogy of a homogeneous equation of n dimensions, which, transform it how we may, must remain homogeneous, Fourier named these *change ratios* the dimensions of the units of the quantities. I should be obliged to Prof. Rücker if he can point to any evidence that Fourier meant more than this.

I need hardly tell "E. M. C." that I do not regard either the theory that electricity is ether (or any other of those enumerated) as a *valid* deduction from the study of dimensional formulæ; but I think the theory was suggested by the fact that the ratio of the two units of quantity is of the dimensions of a velocity, and that that velocity is nearly equal to the velocity of light. The theory is alluded to in Dr. Lodge's "Modern Views of Electricity," but I do not think there is there any hint of its origin. As we know that light is not ether, and are not sure whether electricity may not be, the latter theory is clearly more justifiable than the former.

I do not think the concrete view of units is any great safeguard against the confusion of thought shown in the drivel you quote from the "Book of Instructions, &c.," though the dimensional equations, on either interpretation, afford, perhaps, the readiest way of exposing such confusion. Must I repeat again that I do not consider these equations useless?

I was under the impression that the quantitative relation between E. S. and E. M. units was a matter of experiment, and I fail quite to see your point, when you urge the failure of text books to describe the method of finding it satisfactorily as a reason for regarding a numerical interpretation of units insufficient.

That such relations as "the ratio of a cubic foot to a pound" [? ounce] are unintelligible has been my contention throughout, and it is to avoid such that I would keep concretes out of the equations. Of course no equation can be intelligently interpreted without bearing in mind of what the numbers involved are measures; significant symbols are a great, and legitimate, help in this. To treat the symbols themselves as concretes is little additional help, and tends to introduce confusion and make the equations talk nonsense.

I venture to forward you a "parable," which, on this, and on the educational question, may help your readers to understand my position more readily than any heavy argument could do.

A PARABLE.

Once upon a time a schoolboy was endeavouring to solve a certain equation, and this is what he wrote down on his slate:—

Let $x = \text{oxen}$, $y = \text{sheep}$, $z = \text{rabbits}$;

then $$x + y + z = 100, \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(i.)}$$

and $$5x + y + \frac{z}{20} = £100 \quad . \quad . \quad . \quad . \quad . \quad \text{(ii.)}$$

A humble individual in a black gown, possessed of a university degree, a delicate sense of the niceties of language, and little else, came up at that moment, and, with the mild sarcasm that is the modern substitute for the rod, suggested that you could not very well add together these multiples and fractions of animals, and equate them to a sum of money. The boy felt that he was being blamed unjustly. He could not, of course, put his feelings into words, not having arrived at that stage of mental development which admits of an argument being coherently stated; but his feeling was that he knew what he meant, and that the first line in his solution was intended as a memorandum rather than as an exact statement. What he could do was to finish his problem, and triumphantly inform his master that the result came out all right. He was then told that the criticism applied to the form of his statement of the question, not to the algebraical work, and that slovenly statement was apt to lead to slovenly thought. The boy thought that all rot, but being an obliging fellow he condescended to substitute:—

Let x = the number of oxen.
" y = " sheep.
" z = " rabbits.

And to *suppress* the symbol £ in (ii).

Anyone who knows the average schoolboy will admit that a lad who at fifteen can tackle an indeterminate equation, and who is so ready to yield his superior judgment to the prejudices of his elders, is sure to get on, and stand high in the

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class lists in mathematics. His genius is also likely to be most appreciated at home, where it is least understood, and his father will probably look out for a career for him which will give his special talent full play.

Accordingly, two years later, we find our schoolboy a student in a technical college under charge of a professor who is in all, save a tendency to sarcasm, the very opposite of his former instructor. He has learnt by this time to appreciate for himself the importance of accurate statement as a help to accurate thought; and he is engaged in the elementary task of ormulating Ohm's law. He writes:—

Let E be the number of volts in the E.M.F. of a given circuit.

R the number of ohms in the resistance of the circuit.

Then $\frac{E}{R}$ = the number of amperes of current flowing in that circuit = C.

The Professor comes up and shakes his head. "You are dealing with concretes," he says. "This is *a physical equation* —write

"E volts ÷ R ohms = C amperes,

or, $\frac{\text{E.M.F.}}{\text{resistance}}$ = current."

Suddenly the student remembers those unhappy fragmentary rabbits, and bursts into unseemly laughter. Apology is vain, and explanation impossible, and he is excluded from lectures for a week.—Yours, &c., W. M. M.

[Our allusion was not to the *experimental* determination of the ratio of the E.S. and E.M. units, but to the theoretical connection between the numbers representing in the two systems some electrical quantity such as capacity, and the number representing r.—Ed. *E.*]

THE ACCOUNTS OF THE METROPOLITAN ELECTRICITY SUPPLY COMPANIES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In the interesting analysis of the accounts of the Metropolitan Electricity Supply Companies which you publish in your issue of the 8th inst. you call attention to the fact that the alternating-current companies spend rather more than twice as much as the continuous-current on coal per unit supplied. May I suggest that some additional information might be furnished which would help us to form a better basis of comparison between the two systems than the expenditure on fuel per unit supplied alone? The essence of electricity supply is *distribution*; and the information is not complete unless the cost of the watts supplied is supplemented by some information as to the distance which they are delivered, what are the present relative areas of supply of these distributing stations, or what is the average distance to which each unit is sent. With a map showing the mains and the positions of the consumers and a list of the consumers' meter readings for 1891, it ought not to be very difficult to find the mean radius of supply. If we can consider the squares of these radii side by side with the other figures given in your table, we ought to be able to get a better idea of the relative economy of the two systems; at least, it will be possible to judge whether it is fair to compare them at all.—Yours, &c., Edward W. Cowan.

Bowdon, Cheshire, July 20, 1892.

[This letter is referred to in our "Notes."—Ed. *E.*]

BOOKS, &c., RECEIVED.

"Proceedings of the Royal Society." Vol. LI., Nos. 308, 309, 310. (London: Harrison and Sons.)

"Medical Electricity: A Practical Handbook for Students and Practitioners." By W. E. Steavenson, M.D., and H. Lewis Jones, M.A., M.D. (London: H. K. Lewis, 136, Gower-street. 1892.)

"Journal of the Institution of Electrical Engineers, Vol. XXI., No. 99. (London: E. and F. N. Spon.) Price 3s.

"Proceedings of the Academy of Natural Sciences of Philadelphia." January to March, 1892. (Philadelphia: Academy of Natural Sciences.)

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Tenders Invited.—Our readers are reminded that the tenders for wiring the Town Hall, Hull, are to be sent in by Friday next, the 5th August.

Tenders Received.—The following tenders have been received by the London County Council for lighting Claybury Asylum by electricity, and have been referred to the Asylums Committee:—

Siemens Bros. and Co. (Limited)	£28,400
Messrs. Laing, Wharton and Down	27,982
Messrs. B. Verity and Sons	26,471
Ropers' Electrical Engineering Company (Limited)	23,966
Messrs. Paterson and Cooper	22,540
Messrs. J. D. F. Andrews and Co.	21,000
Fowler, Lancaster, and Co. (Limited)	20,549
Messrs. Drake and Gorham	20,500
Electric Construction Corporation (Limited)	19,932
Messrs. Hammond and Co.	19,900
Mather and Platt (Limited)	19,250
Messrs. Johnson and Phillips	19,200
Manchester Edison-Swan Company (Limited)	18,850
Messrs. Bourne and Grant	18,808
Messrs. Sharp and Kent	18,540
Messrs. J. D. Statter and Co.	18,128
Edmundsons (Limited)	17,737
Crompton and Co. (Limited)	17,500
J. E. H. Gordon and Co. (Limited)	17,337
Messrs. Appleton, Burbey, and Williamson	16,500
Brush Electrical Engineering Company (Limited)	15,800
Latimer Clark, Muirhead, and Co. (Limited)	15,130
Mr. F. M. Newton	14,105
Woodhouse and Rawson United (Limited)	13,970

The Holbeach Local Board on Thursday last week opened tenders which had been received for lighting the streets by electric light, gas, or oil, the latter illuminant being finally chosen.

Tenders Accepted.—The Electrical Committee of the Bristol Town Council have accepted the tender of Woodhouse and Rawson United (Limited) to supply the condensing plant for the large electric light installation in progress, for the sum of £3,752. The Council also decided to take the opinion of their engineer upon various suggested improvements in the posts to be used for the public lighting.

Appointment Vacant.—The Dundee Gas Commissioners desire to secure the services of an electrical engineer to inspect the works during construction and to manage the same after construction.

Messrs. King, Mendham and Co.—This firm have obtained the contract for the electric lighting of the new offices of Messrs. John Lysaght (Limited), St. Vincent Iron Works, Bristol. The installation will consist of 110 lamps, and these will be run either direct from the dynamo or from a set of accumulators.

Plant for Sale.—Messrs. Wheatley Kirk, Price, and Goulty have for sale a quantity of useful plant, all by well-known makers, including several small vertical and horizontal engines, with and without dynamos. Further particulars are given in our advertisement columns.

Trowbridge.—At a meeting of residents on Thursday last week it was decided to request the Local Board to endeavour to get the Local Government Board to either take up the matter of the electric lighting of Trowbridge, or to modify their present unfavourable attitude to a private company making the installation.

Bacup.—The Corporation have been making inquiries amongst the tradesmen and others as to the likelihood of their adopting the electric light in case the Corporation should furnish the necessary plant. The Corporation's powers to supply electricity for lighting purposes will expire next month.

Werrington (Staffs.).—At the quarterly meeting of the Staffordshire County Council on Tuesday last, the Industrial (Boys) School Committee asked the sanction of the Council for the adoption of electric lighting at the Werrington Industrial Schools, in preference to the present system of lighting by oil lamps. It was estimated that the outlay required would be, including buildings, from £835 to £926, and the annual cost of maintenance and depreciation from £80 to £90. In spite of some opposition the Council decided in favour of lighting by electricity.

Weybridge.—At a meeting of inhabitants on Thursday last week Col. Martindale, chairman of the Laing, Wharton, and Down Construction Syndicate (Limited), explained at some length what the Syndicate proposed to do in regard to the electric light at Weybridge, and a committee was appointed to confer with the Directors.

St. Mary's Cathedral, Newcastle-upon-Tyne.—This cathedral has just been fitted up for the electric light by Messrs. R. J. Charleton and Co., who have replaced each of the old gas lamps.

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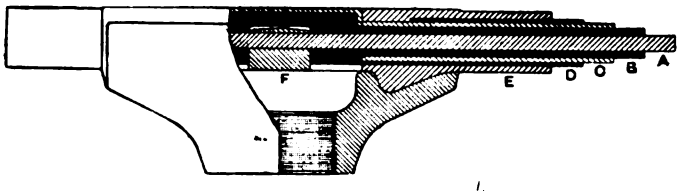
with a 100 c.p. incandescent lamp, the current being supplied by the Newcastle and District Electric Lighting Company (Limited).

SURVEYORS' INSTITUTION, LONDON.—The electric light is about to be installed at this Institution, under the superintendence of Messrs. Morgan Williams and King, the contractors for the work being Messrs. Pyke and Harris.

MAVOR AND COULSON'S CONCENTRIC WIRING.—In *The Electrician*, Vol. XXVII., p. 183, we described several details of this concentric wiring system, and we illustrate a new junction box, of which a sample has been sent to us. This consists of a brass box with necks to take the main conductor. These necks are enlarged into pockets in the brass casting, and fusible metal is run in, making connection with the outer conductor. In the sample which we have received the outer conductor consists of a spirally-wound copper tape, and over this is a thin insulation and a lead covering. The illustration shows the central conductor A, a fibrous impregnated insulation B, a spiral tape conductor C, thin insulation D, and a lead covering E. A contact piece F soldered to the central conductor, and backed by a disc of insulating material, is provided for making a butt joint with the branch conductor. The outer connection is made through the brass casting, into which a nipple is screwed. By slacking off a jam nut the branch may be unscrewed and removed. Distributing boxes and other details have been made, and the advantage is offered that all fittings, &c., may be wired complete before erec-



tion, being merely screwed together in place. We understand that the requirements of the Phœnix Office are met; and if the earthing of the middle conductor of the three-wire system becomes general this mode of wiring ought to be widely adopted. Messrs. Mavor and Coulson have forwarded us drawings showing various other details, the conductor being provided in some cases with a stranded wire sheath as well as a lead covering. Special arrangements of the system have been made to suit the requirements of the Home Office for the dangerous portion of the dynamite factory of Nobel's Explosives Company.——This firm have acquired the business of engineers and machine makers lately carried on in Glasgow by Messrs. Kellock and Galbraith.

MESSRS. CURTIS BROTHERS.—This firm have opened premises at 10, Suffolk-street, Dublin, where they intend carrying on business as electrical engineers and scientific instrument makers.

MESSRS. EVANS, STEWART, PALMER AND CO.—This firm have secured the contract for fitting up an electric light installation at the offices of the Gophir Diamond Company, Regent-street, W.

ANNUAL OUTING.—Mr. Edward Gimingham, the manager of the Edison and Swan Company's works at Ponder's End, entertained the works staff, numbering 54, to dinner at the Rye House on Saturday last. The weather was all that could be desired, and a most enjoyable day was the result.

FIRE IN CHANCERY-LANE.—Mr. C. Purcell Taylor, D.Sc., writes to inform us that, although all his apparatus was destroyed in the fire on Friday, his library is intact, and the most important of the Government and private papers have been saved.

MR. ARTHUR STANBURY.—This gentleman has just completed on the premises of Mr. J. M. Coole, Douglas, practically the first private electric light installation in the Isle of Man. The plant comprises a Norwich dynamo, driven by a gas engine. The lights are distributed throughout the warehouse, shop, and residential portions of the building, and consist of 26 16 c.p., four 25 c.p., and four 50 c.p. Edison-Swan lamps. Mr. Stanbury has also recently fitted up Messrs. Singer's Stall at the Exhibition now being held in Douglas.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

June 20, 1892.

11,487. R. F. JEFFRIES. London. An apparatus for erecting top and middle sections of telephones and other poles.

11,525. G. G. M. HARDINGHAM. London. Apparatus for use in manufacturing electric cables. (Felten and Guilleaume, Germany.)

11,526. G. G. M. HARDINGHAM. London. Improvements in electric cables. (Felton and Guilleaume, Germany.)

11,528. J. A. C. ZIEGLER, W. R. RUTLEDGE, and F. E. ALLAN. London. Improvements in dynamo-electric machines and motors.

11,532. W. A. BOESE. Liverpool. Improvements in secondary or storage batteries.

June 21, 1892.

11,548. C. S. SNELL and WOODHOUSE AND RAWSON UNITED (LIMITED). London. Improvements in connection with lubricators used on dynamo-electric and similar machinery.

11,592. C. K. MILLS. London. Means for operating ammeters and other electrical apparatus. (H. M. Pilkington and R. S. White, United States.)

11,617. C. J. HALL. London. Improvements in or relating to dynamo machines.

11,624. H. H. LAKE. London. Improvements in coin-operated telephone apparatus. (E. Noreiga, Mexico.)

11,634. F. WYNNE. London. Improvements in or relating to electric railways.

11,640. F. H. NALDER, H. NALDER, C. W. S. CRAWLEY, and A. SOAMES. London. Improvements in electric meters.

June 22, 1892.

11,664. E. PAYNE. London. Improvements connected with tubular electric conductors and their insulation.

11,672. R. E. B. CROMPTON and S. L. BRUNTON. London. Improvements in armatures for alternate-current dynamo-electric machines and motors.

11,692. F. PURDON, H. E. WALTERS, B. MOTT, and J. P. O'DONNELL. London. Improvements in electric locomotives.

11,698. F. MEYER. London. Improvements in insulators for overhead and other electric wires.

June 23, 1892.

11,736. J. SWINBURNE. Teddington. Improvements in and connected with electric dynamo machines, distribution by means of transformers, organs, and the reduction of zinc.

11,779. G. F. REDFERN. London. Improvements in the manufacture of carbons for electric arc-lamps. (Carl Braun, Germany.)

11,807. R. KENNEDY. Glasgow. Improvements in and relating to the measuring of electricity, and in meters therefor.

11,822. H. ARON. Liverpool. Improved means for electrically winding up the weight for driving clockwork and other mechanism.

11,833. H. ARON. Liverpool. Improvements in apparatus for measuring electric currents.

11,835. E. J. FINOT. London. Improvements in the process and apparatus for tanning hides and skins with electrolytic action.

11,849. S. BERGMANN. Glasgow. Improvements in distribution and branch boxes for electric circuits.

June 27, 1892.

11,941. H. W. MILLER. London. Improvements in electricity meters.

11,948. H. CORTLAND. London. Improvements in electric fire-alarm and circuit controlling thermostat and clock mechanism.

11,952. J. W. JONES. Balham. Improvements in electric meters.

June 28, 1892.

11,969. J. H. HIRST. Kingston-upon-Hull. Telegraphic (including telephonic) communication between lightships and the shore.

2,039. T. FLOYD. London. Improvements in the construction of electric railways and appliances therefor.

12,040. J. E. A. GWYNNE. London. Improvements in and connected with arc electric lamps.

12,044. G. H. JONES. London. Automatic supply of electricity.

June 29, 1892.

12,087. F. W. SCHINDLER-JENNY. London. Improvements in electric heating devices, and contacts for the same.

June 30, 1892.

12,191. B. J. B. MILLS. London. Improvements in electric railways. (E. H. Johnson, United States.)

July 1, 1892.

12,212. J. M. BRADFORD. Portland. Electric regulating apparatus.

12,238. B. SCHERTHANER. London. Improvements in and apparatus for producing and utilising electric currents.

12,246. Y. A. M. P. GOUBAUX. London. Improvements in electrica meters.

12,258. P. SCHARF. London. Improved electric glow lamp.

July 2, 1892.

12,295. W. HABGOOD. Buckingham. Improvements in electric arc lamps.

12,306. J. B. LEE. London. Improvements in the construction of secondary batteries for electrical storage purposes.

12,311. C. DARRAH. Manchester. Improvements in electric theft-prevention alarms.

July 4, 1892.

12,359. F. F. BENNETT and H. CURWEN. Preston. Working by electricity weaving and spinning machinery.

12,381. E. B. BRIGHT and M. BAILEY. Esher, Surrey. Improvements in the manufacture of plates for storage batteries or accumulators, and the accessories thereto.

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12,382. R. D. Sanders. London. Improvements in the manufacture of wire, strips and the like by electro-deposition.
12,396. J. A. Timmis. Westminster, London. Improvements in the lighting of railway trains electrically.

July 5, 1892.

12,397. J. Sayers. Derby. An improved method of regulation of the potential difference of electrical conductors, more particularly with regard to the variation caused by the varying current in the middle or "third" wire of a three-wire system.
12,417. W. Mitchell. London. Electric brazing and soldering devices.
12,436. H. H. Lake. London. Improvements in electric insulators. (L. McCarthy, United States.)
12,442. L. D. Adler, J. Loewenburg, S. Young, and M. Moskowitz. London. Improvements relating to the lighting and heating of railway and other vehicles by electricity.

July 6, 1892.

12,468. J. Edmundson and J. Oulton. Halifax. Improvements in electricity meters.
12,476. F. Brown and A. Cheetham. Walsall. An improvement in induction coils for medical purposes.
12,506. R. H. Jones. London. A new improved telephone transmitter.
12,511. E. Willans, widow and administratrix of the late P. W. Willans. London. Improvements in electro-magnetic clutches.

July 7, 1892.

12,528. G. L. Anders and W. Kottgen. London. Improvements in telephonic apparatus and switches.

July 8, 1892.

12,618. L. Schramm and S. T. Wyand. London. An improved combination wall socket and switch for electric currents.
12,619. L. Schramm and S. T. Wyand. London. An improved electric switch.

July 9, 1892.

12,655. P. Willis. London. Improvements in conduits for electric or cable-roads. (C. H. Bates, W. A. Miller, and W. Ragan, United States.)

July 11, 1892.

12,691. S. F. Walker. Cardiff. Improvements in electro-magnetic apparatus for controlling electric light and power circuits.
12,700. D. W. Peaks. Northampton. A new or improved apparatus for carrying or conveying telegraph or telephone wires over houses or buildings.
12,731. Siemens Bros. and Co. (Limited). London. Improvements in electrolytic extraction of zinc. (Messrs. Siemens and Halske, Germany.)
12,735. J. C. Fuller and G. Fuller. London. Improvements in supports for telegraph insulators.
12,737. T. Jenner and G. B. Wilkes. London. Improvements in electrical switches and incandescent lamp holders.

July 12, 1892.

12,745. H. J. Allison. London. Electric signalling apparatus. (The Standard Electric Signal Company, United States.)
12,759. W. P. Thompson. Liverpool. Improvements in or relating to electric railways, especially those in which underground conduits are used, and in rolling stock for the same. (A. H. Hieatzman and H. D. Hieatzman, United States.)
12,807. A. W. Money and H. Nash. London. Improvements in apparatus for regulating the arc in electric arc lamps.
12,818. J. E. Evans-Jackson. London. Improvements in conduits for electric railways. (C. L. Travis, United States).

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

9,915. Swinburne and Holt. Electrical distribution.
11,886. Cance and Others. Electric arc lamps.
12,099. Maquay. Electric motors.
12,416. Marr. Telephonic receivers.
12,535. Newton (Swan.) Electric switches.
13,114. Parker. Electric furnaces.
13,387. Cazal. Dynamo-electric generators.
13,628. Hartnell. Electric dynamos.
13,926. Atkinson and Others. Electric locomotives.
14,063. Marr. Telephone transmitters.
14,171. Grimston. Electric cars.
14,859. Gimingham. Incandescent electric lamps.
14.987. Siemens Bros. and Co., Limited, and Others. Electrical drill.
15,240. Siemens Bros. and Co., Limited, and Hird. Dynamo electric machines.

1892.

3,881. Kahabka. Electrical accumulators.
7,172. Bradley. Electrical surgical instruments.
8,463. Coerper. Electric arc lamps.
9,136. Thorn. Electric alarms.
9,282. Abel. (Société Générale des Téléphones.) Telephonic installations.
9,380. Burton. Converting electric currents.
9,470. Lake. (Jörns.) Electric pushes.
9,537. Toye. Body batteries for curative purposes.
9,541. Schmalhaus. Electric accumulators.
9,863. Lake (The Electric Secret Service Company). Electric signalling apparatus.

COMPANIES' MEETINGS & REPORTS.

Eastern Telegraph Company (Limited).

The fortieth half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held on Friday, July 22, 1892, at Winchester House, 50, Old Broad-street, London, under the presidency of Sir John Pender, K.C.M.G., M.P.

The SECRETARY (Mr. Draper) read the notice convening the meeting and the minutes of the last general meeting.

After signing the minutes, and the report and accounts having been taken as read,

The CHAIRMAN said: I will make a few remarks, as I have generally done at the many meetings at which I have had the pleasure of addressing you. The gross revenue for the half-year under review amounted to £382,207, as against £383,307 in the corresponding period of 1891, or a decrease of £1,100. The small decrease of £799 in the message receipts is principally caused by the loss of revenue from the reduction in the Australian tariff, and by small decreases in the receipts from other sources, notably South Africa; but these reductions have been almost counterbalanced by the growth of traffic in other directions. The revenue from our investments in other companies, with the exception of the Direct Spanish Company, remains the same.

The total ordinary expenses for the half-year ended March 31, 1892, amounted to £105,820, as against £102,020, or an increase of £3,800, the details of which are as follows:—General expenses in London £9,589, as against £9,503, or an increase of £86. The working expenses at the stations were £78,695, as against £75,003, being an increase of £3,692. The principal increases are in salaries, rent, fuel and light, repairs and renewals of furniture, and repairs to stations, &c. The first item is due to an increase in the number of our foreign staff to work the Aden-Bombay triplicate cable, and to cope with the increased number of messages caused by the reduction of tariff to Australia and the normal growth of traffic. The number of messages carried in 1890 was 1,276,368, and in 1891 1,399,755, or an increase of 123,387, so that we are not going back. A portion of the increase is also due to the ordinary promotions, which depend in a great measure upon the clerk acquiring a certain standard of speed and accuracy in his work. Our policy has always been to improve the speed and accuracy of all classes of traffic, whether we are in competition or not; and we believe this object can be best attained by encouraging our staff to do their best, and rewarding those who show the best results. Our experience goes to prove that the more we can improve the service rendered to the telegraphing public, especially as regards speed and accuracy, the greater will be the number of messages sent.

Additional accommodation has been necessary for the increased number of staff, and important improvements have been effected at several of the stations, which will materially add to their comfort: and, with a due regard to the health of the staff, the sanitary arrangements have been carefully inspected, and improvements carried out wherever it has been considered necessary to do so. I need not tell you that if we were to take up our stations abroad and occupy them as we first found them they would not prove very wholesome homes for our staff. We have always thought that if we are to get good work we must put our staff in as comfortable and healthy positions as possible, so that there will be no sanitary drawbacks in connection with the work they have to do. I believe that throughout the Levant at the present moment where we have stations they are in as satisfactory a condition as possible, so far as regards sanitation. We are pleased at being constantly complimented about our stations; and visiting them sometimes, as I do, I am very glad to say that our stations are such that we have just reason to be proud of them, and, comparatively speaking, we have considerably below the average of cases of disease. We are gainers in the long run by this, because a sick clerk costs us a good deal of money, while a healthy clerk gives us better work, and consequently the more satisfies our requirements.

Included in this half-year's figures is a sum of £4,000 carried to the maintenance ships reserve fund, against £3,000 in the same period of last year, or an increase of £1,000. The expenses attending the repairs and renewals of cables amounted to £53,515, as against £53,144, or an increase of £371. As will be seen from Abstract C, our ships have been fully employed carrying out the important work of repairs and renewals, not only for our own account, but for account of the Brazilian, the South African, the African Direct, and the Direct Spanish Companies. I was asked the question last year whether our repairing ships obtained any return or profit out of these repairs, and I am therefore glad to be able to tell you that this half year the money accruing from these repairs has given us something like £15,000.

A very expensive repair was effected in our original Aden-Bombay cable and a considerable length of new cable was laid in, which will add to its efficiency and give it longer life. We are getting into a period when we have to look to the life of these cables. We have expended a great deal of money on them out of income in the last twenty-one years, and the additions which we have thus made to our cables give us hope that we shall prolong their life for a very considerably longer period than we expected when we first began our work.

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After providing the usual amounts for interest on debentures, debenture stock, and preference shares, we are able to propose the usual final dividend of 1½ per cent, and bonus of 1½ per cent., making with the interim dividends already paid a total distribution of 6½ per cent. for the year ended March 31, 1892, and carry the sum of £68,000 to the reserve fund. I think you will agree with us that that is a very satisfactory state of things, and it shows, I think, that you have behind your investment something that will back it up, and enable us to go on with our work, doing it efficiently, and still maintaining what we consider in these days a very good dividend indeed.

After applying from the reserve fund a further sum of £72,773 towards the cost of the Aden-Bombay triplicate cable and other expenditure, the general reserve fund amounts to £442,014; and the total sum applied from this fund for new cables, &c, now amounts to £1,174,235. You therefore see that we have been using our reserve fund in a way largely to increase our system, while keeping down the capital and still maintaining the payment of good dividends.

Now, gentlemen, I come to a question which I think you were all pretty unanimous on when I last addressed you, namely, the fund for the benefit of our *employés*. We have brought that now, practically, I may say, to a conclusion. We have threshed it out thoroughly. We have had advice from the best actuaries of the day on the matter, and we have come to the conclusion that what we are going to do is for the benefit of our staff, and to make our service one of the most popular of any class of industry in the country. In this particular industry, as I have before stated, we require honest, intelligent, bright men; and unless we show some inducement for the future we cannot have that class of men. Our staff, I may say, are thoroughly satisfied with the course we have taken. We have consulted the leading members of our staff as to the best way of dealing with this question, and the whole thing has now been threshed out, and is in a thoroughly satisfactory position. I am, therefore, going to ask you to pass a resolution empowering us to bring the whole question into practical working. A full and complete statement of the whole business can be seen by any shareholder at the office, or it is on the table if anyone wishes to look through it after the meeting. It is, however, too long for us to go into in detail; but you have trusted us so long that I dare say you will not withhold from us your confidence to day in regard to this matter after what I have told you.

Mr. BAINES: I think that we ought to have some outline of the details of the proposal.

The CHAIRMAN: I think I can shorten the proceedings a little by condensing what I intended to say on the matter. The shareholders having at the last meeting approved the principle of establishing a staff pension fund, your Directors have had a scheme prepared by experienced actuaries, who advise that an annual contribution by the Company of 2½ per cent. on the salaries, and a similar contribution by the staff, would, if invested at 4 per cent. compound interest, provide sufficient funds to make adequate retiring allowances for the younger members of the staff on their attaining 60 years of age; but as many of the older *employés* have already seen considerable service, and their retirement in some cases cannot be far distant, 2½ per cent. would be insufficient to place them on an equally favourable footing. With a view, therefore, to supplementing their allowances from the pension fund, the actuaries advise that, in addition to the 2½ per cent. just referred to, the Company should continue their present contribution to the endowment assurance fund in full until all the existing policies are paid off, and allow the savings effected by the premiums ceasing to be payable to the assurance company, as the policies mature from time to time, to be applied exclusively for the benefit of the older servants. The wish that the older servants should not be placed on a less favourable footing than the younger members of the staff was strongly expressed at the last meeting. The actuaries further recommend that the Company should guarantee 4 per cent. interest on the accumulations of the fund. Provision is also made in the actuarial calculations for dealing with cases of death or breaking down in health before reaching the retiring age, and for other contingencies. This is a fair outline of the actuaries' scheme; but as certain details are still under consideration by the Board, it is proposed to ask you to-day to approve a resolution in general terms empowering your Directors to bring the scheme into operation when the details are finally settled. The report of Messrs. Neison and Schooling to which I have referred is laid on the table, and as it is a long and elaborate document it can be seen at any time at the Secretary's office. You have now got to know about as much as we do ourselves concerning this matter. The whole scheme is based upon sound principles. We have employed the best actuaries to deal with it, and what we ask from the Company is not a very excessive sum, and we believe that it will help our staff in their duties and make them look forward to a brighter prospect in future, while we shall continue to pay a good dividend.

I think I have now said pretty much all that is necessary to be said in regard to details, but I may add two or three more words. Looking at the notes of our meetings for the last two or three years I find that I have given you such an amount of information that I am satisfied when you come here six months after six months you find that you know thoroughly the working of this great Company. We have given you every information, and kept nothing back. We have felt that if we are to be strong ourselves we must be strong through the support of our shareholders. We have acted on that principle. I do not believe there is any company that can show a better or more satisfactory position in England.

Our general telegraph system is working well, but I cannot say that there is any time when it is throughout in perfect working order. Still, all our system is under such control that there is no fear in regard to the maintenance of our communications. We have duplicate and, in some cases, triplicate cables, and we are therefore able to carry on our system so satisfactorily that you will be astonished, looking at the large amount of work involved by our system, when I tell you that we have only had one letter regarding this meeting to-day, and that of a complimentary nature. So satisfied is the gentleman who wrote this letter that he would travel a considerable distance if he thought it were necessary to come and support the Directors. We have had no letter of complaint of any kind.

We hear whispers abroad that the merchants think that our tariffs ought to be reduced. We, however, understand our business thoroughly, and I think that if the merchants came in a deputation to us about this matter, I should be able to satisfy them that we have done them a great deal more benefit by our system than we have received from them. I have been a merchant for 50 years of my life, and I know all the ins and outs of mercantile life. I know how enormously beneficial to the general trade of the country this submarine telegraph system is, and the merchants have got the full advantage of it, and it is so cheap in view of its great benefits that it makes a comparatively small item to what it did a few years ago in their expenses. Every man must be paid for his labour. We have met every case which we felt that it was our duty to meet with a view to extend the traffic. I think we have been successful in what we have done, and I believe I may say, without hesitation, that nine-tenths of the great operations of this Empire are begun and ended by telegraphic communications. I thank you for listening to me as you have done, and if any gentleman has any question to put I shall be glad to answer him. I will, however, first propose the resolution, which is as follows:—

"That the printed report and accounts of the Directors to 31st March, 1892, submitted to this meeting, be and the same are hereby received and adopted; that a dividend on the preference shares of the Company to 30th June, 1892, at the rate of 6 per cent. per annum be paid, less income tax; and that, in accordance with the Directors' recommendation, a dividend be and is now declared of 2s 6d. per share, with a bonus of 3s. per share, both free of income tax on the ordinary shares of the Company, making, with previous payments by way of dividend on account, a total payment of 6½ per cent. on those shares for the year ended 31st March, 1892."

The VICE-CHAIRMAN (the Most Hon. the Marquis of Tweeddale): I beg to second that.

The CHAIRMAN: If any gentleman has any question to ask I shall be glad to answer him.

Mr. ROBERT SNARE: I wish to ask if you have any idea of the amount that will be required for this pension fund. I only ask the question as it will go before the public and the shareholders, and it will be satisfactory to them to know that it is such a small sum; and we may be pleased to grant more if it is necessary.

The CHAIRMAN: It will cost us about £2,000 more than we are paying at the present moment.

Mr. BAINES: You have all heard what the Chairman has said. You have noticed that there is a little falling-off in some respects in our revenue, with an increase in the expenditure. I joined this Company a great many years ago, when it was in sections; and prospects were then held out of 10 per cent. and 12 per cent. We have, however, never realised those dividends—not that I am going to charge the Board with any want of ability, for they have had to meet circumstances which they could not foresee; but now that the Company has got in a prosperous condition it is paying, I admit, a fair dividend, although I do not think it is by any means an extravagant return, considering the risky nature of the business. You may get to-day perfectly safe debentures to pay you 4 per cent., and for the risky character of our business we get this 2½ per cent. extra. There is a tendency in the present age to make every company a sort of popular institution. I have myself been employed by firms, but I have never found them help me in the way suggested, or hold out any such prospects to me in regard to the future. The difficulties of certain companies are very serious. The Great Eastern Railway Company at the present time is showing a marked falling-off in its dividend, and why? Because wages have increased and materials have increased, and the consequence is there is less money to divide. I should think it would be wise on the part of the Directors if they were to postpone this matter—at all events, until such time as we have the complete scheme before us. I hope that the Directors will take this suggestion into consideration. I do not consider that this dividend of 6½ per cent. affords any ground for being proud of our position. It is a very fair return, but I do not think it is anything to go into ecstacies about.

The CHAIRMAN: The solicitor reminds me that the whole thing is complete, and only requires this resolution to be passed to carry it into effect.

Mr. BAINES: That may be, but we have not the complete scheme in our mind.

The CHAIRMAN: If you want to get this complete scheme into your mind you had better spend a couple of hours at the office, and you can satisfy yourself. I am quite sure that were I to read that document to-day, and spend all the time that would be necessary to do so, a great many of us would not be much wiser at the end than they are now. We have taken the best people into our confidence, and have done everything we possibly could to establish a fair and just system. I should myself deeply regret if I could think that in after years, when a younger class of people are here, and probably a younger class are addressing you, there should be any reflection thrown upon myself or my colleagues for having done anything unjust either to the shareholders or to those who serve us. The whole system is based upon justice, and upon that justice we stand; and I am perfectly satisfied in the course we have taken, knowing that the men I am addressing will back us up. On the last occasion I addressed you we were pressed to go on with this scheme. The feeling was so strongly in favour of it that we did not hesitate. Now, this gentleman throws doubt upon it—not that I attach any value to his doubts, because I am sure that the shareholders will support the Directors in passing this resolution to-day, and unanimously.

Mr. JOHN NEWTON: I should like to say a word or two. Years ago when I first became a shareholder our property stood at 7½ in the

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market, and we were receiving disappointing dividends—5 per cent. I was one then who thought that we ought to have a dividend something like what had been promised to us in the prospectus; but events move on, notwithstanding prospectuses; and you know that the merchants of this country, and of every other country, too, are very clever, and can circumvent you in your ideas about 15 per cent. dividends by what they themselves can do. Moreover, the various Governments have come and said that we must reduce our tariffs. In spite of all that, what has taken place? You see your property since then doubled in value, and it is now established on such a basis that it ranks among the highest class of investments. In old days it was said that your cables would only live 10 or 12 years, but I always said 20 years; and certainly their life has been greatly prolonged beyond what was at one time thought would be the case. Not only has your property doubled in value, but it stands at that value and has done so for some time. I do not know how long ago it is since our shares got to 15, but I believe they have been for the last two months standing steadily at that price. Look at the advantage of that—of your having a solid steady property, upon which you are getting a dividend of 6½ per cent. You may say, what is 6½ per cent. in comparison with the dividends that are paid elsewhere—that were paid years ago by many other companies? But where are those companies now? Where is the position of a great many investors now compared with what it was a few years ago? Probably no class of security stands higher than telegraph property now; and I say that the staff who have worked for you in foreign parts ought to be most jealously and well looked after, and when they go out to their service they ought to be well looked after by you. It is a very different service from that of a man who works for a railway company. Remember you have no union to contend against. If you had a property that unionists could interfere with, you would have to give up some of your dividend to that influence. I think that we have every reason to be satisfied and proud that you have brought forward this scheme in recognition of the services of the staff who work for you, and it will give the staff a greater interest in the Company. The 2½ per cent. which the shareholders are now asked for, as the Chairman has mentioned, is a fleabite compared with the advantages which we may expect to derive from the scheme.

The CHAIRMAN then put the resolution that the report and accounts be received and adopted; and declared it to be carried unanimously.

The CHAIRMAN: I now propose—

"*That the report of Messrs. Nelson and Schooling, of the Institute of Actuaries, relative to the establishment of a staff pension fund having been submitted to the meeting, the Directors be and they are hereby authorised to cause such deed or deeds or other documents to be prepared as they may consider necessary for carrying out the scheme embodied in the said report, with such alterations and modifications, if any, as may be approved by the Directors.*"

That is the resolution which I now propose with respect to the fund for the staff. The resolution will be seconded by Sir James Anderson, who takes a very deep interest indeed in the staff, and who, I am perfectly satisfied, considers that the decision which his Board has come to is a just and fair decision, having reference to the thoroughly efficient working of the concern, and working it through good and reliable heads.

The MANAGING DIRECTOR (Sir James Anderson): In seconding this resolution I will just say one or two words. A very great feature of our service is the necessity of keeping our young men with us when they become proficient. They learn to become proficient, and then a great many leave us for other professions, and the loss of these men is a decided loss to us and the shareholders. I have favoured this pension scheme more on that account almost than anything else, because it will knit our young men to our interests and to the service, and make them proud of the Company to which they belong. I second the resolution with very great pleasure.

The CHAIRMAN: Those in favour of the resolution will please to hold up their hands. To the contrary. Carried unanimously. I think that that concludes the business of the meeting; and I am pleased to find that the feeling so strongly expressed six months ago is so unanimously confirmed to-day. It will carry to the staff a gleam of sunshine which, you may depend upon it, will benefit your interests while you are benefiting theirs, and will add considerably to the strength and prosperity of this great Company of which we are so proud.

Mr. NEWTON: Before the meeting separates I propose a vote of thanks to the Chairman and Directors; and I congratulate the Chairman on the success which he has just achieved in the northern part of this island. I may be trespassing, perhaps on dangerous ground, but I cannot refrain from expressing the hope that your services there, Sir, will be as successful as they have been here.

Mr. SNARE: As an old shareholder, I have great pleasure in seconding the resolution.

The resolution was carried unanimously.

The CHAIRMAN: I thank you very sincerely for this vote and for the kind words which have been said in regard to myself. Of course, we do not know any politics in this Company, as a company. I dare say many of my friends thought I was a very bold man in having entered rather actively into political life at the present moment; but I have had a good deal to do with building up this great Empire. I have had fifty years of a pretty active life, and I think I find the country better and greater and more respected throughout the world to-day than it was fifty years ago. I should not like, even at my time of life, to take any part in pulling down that Empire; and while I have got a little vigour, a little courage, and a little life left in me it will all be devoted to the maintenance of the Empire, and, in connection with it, this great telegraphic system of ours, which has done more to knit the world together than anything else.

The proceedings then terminated.

West African Telegraph Company (Limited).

The seventh ordinary general meeting of this Company was held on the 22nd inst., at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G., M.P.

The ACTING SECRETARY (Mr. J. Cambrook) read the notice calling the meeting, and afterwards the minutes of the last meeting, which were confirmed by the present meeting, and signed by the Chairman.

The CHAIRMAN: Gentlemen, you have had the report in your hands for some days, and I presume you will take it as read; but before asking you to approve it, I shall make a few remarks, as usual, on the present position of the Company's affairs. Our revenue for the year 1891 amounted to £60,214, as against the takings for 1890 of £68,377, showing a decrease of £8,163. There is a decrease in the Cape joint-purse traffic and the traffic with the French stations; but this is nearly counterbalanced by the increase in traffic with Portuguese and British stations and with South America and local traffic. The principal cause of the reduction in our revenue is the serious depreciation of the Portuguese currency. As will be seen from the accounts, there has been a total loss on exchange of £7,011, nearly the whole of which is due to the loss on remittances between Portugal and England. This matter is receiving the serious consideration of your Directors, and negotiations are pending with a view to a satisfactory settlement. We have been endeavouring to obtain the consent of the Portuguese Government to raise our rate of collection on the West Coast, and the suggestion has been favourably received. Should the matter be formally sanctioned it will to a certain extent minimise the loss on exchange. Fortunately, the money collected in Portuguese currency on the coast has been used for general expenses at the various stations, and the Company has thus been saved a further loss of £2,700, which would have been incurred had the money been remitted to London. The total working expenses for 1891 amounted to £20,883, against £21,685, or a decrease of £802. Several of the items show an increase and others a decrease, the principal decrease being under the heading of working expenses at stations, which are less than last year by £394. Repairs to cables amounted to £2,213, against in 1890 £4,788, or a decrease of £2,575. The balance available for dividend and reserve fund is 12,639, against £17,570, or a decrease of £4,931. It is proposed, therefore, to pay a final dividend of only 2½ per cent., making, with the interim dividend already paid, a total distribution of 4 per cent. for the year, and to carry the balance of £3,395 to the general reserve fund, which now amounts to £30,693. The real question, gentlemen, at the present moment is that of exchange; I cannot hold out very much hope of Portuguese finances improving greatly, but I think that by raising our rates we may be saved from the very serious loss which we are now sustaining. There is another feature in our business which I should mention—namely, that there has been general depression over Africa. People at the Cape are now passing through a phase of depression; but there is such vitality in the country that I have no hesitation myself in coming to the conclusion that brighter days will come again for the Cape, and that with these brighter days we shall have increased traffic, and consequently increased revenue. While the report is not very satisfactory, it is not very unsatisfactory; and taking the ups and downs which occur in the beginning of a telegraph system—which has more or less to be nursed and developed—I think our prospects are upon the whole very favourable indeed. We do not possess the healthiest stations at which to work this system of telegraphy, and, therefore, we have to be very careful in seeing that our staff at the different stations are well looked after. We give them comfortable homes, and do all that we can to ameliorate the conditions of the climate for them; and we feel satisfied that in doing that we are not only benefiting the interests of the Company generally, but also securing for ourselves a class of operators better than we could obtain if their life was left uncertain. With these remarks I beg to move the following resolution:—

"*That the report and accounts for the year ended December 31, 1891, submitted to this meeting, be and they are hereby received and adopted; and that a dividend be now declared, payable on and after this day, of 5s. per share, free of income tax, making, with the dividend already paid, a total distribution for the year of 4 per cent.*"

Sir HENRY C. MANCE, C.I.E., M.Inst.C.E., seconded the motion which was carried unanimously.

The Managing Director (Sir JAMES ANDERSON): I have much pleasure in proposing the following resolution:—

"*That Sir John Pender, K.C.M.G., M.P., and Robert K. Gray, Esq., be, and they are hereby, re-elected Directors of this Company.*"

Sir HENRY MANCE seconded the motion, which was unanimously adopted.

The CHAIRMAN: I am very much obliged to you, gentlemen, for this further evidence of your confidence in me, and I hope I shall be able to show you that it is not misplaced.

Mr. EAST then proposed the re-election of Messrs. Deloitte, Dever, Griffiths and Co. as auditors for the current year, at a remuneration of 50 guineas per annum.

Mr. KENNETH ANDERSON seconded the motion.

The CHAIRMAN put the resolution, and having declared it carried, said: I may mention that Mr. Robert Gray would have been here to-day, but he has a brother who unfortunately is now ill with fever in Brazil; and, like the kind brother he is, he has gone off post haste to visit his relative in what I hope will prove only a temporary illness. I am sure you will all sympathise with him, as we do.

Mr. CUNLIFFE OWEN proposed a vote of thanks to the Chairman and Directors for their able conduct of the Company's affairs. He thought that they might also congratulate the Chairman on his recent parliamentary success; for, apart altogether from politics, they could rejoice at the knowledge that their interests would now be watched over in Parliament by a very able representative.

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Mr. EAST seconded the motion, which was unanimously agreed to.

The CHAIRMAN: I thank you very much on behalf of my colleagues and myself. We are all very much interested, as you know, in the maintenance of this great Empire. Our submarine telegraph companies have done something to bind the Empire together; and, even as an old man, I thought it was my duty to come forward—although some might think it foolish at my time of life—and assist in keeping together that which we have all worked so hard to build up.

The proceedings then terminated.

Globe Telegraph and Trust Company (Limited).

The nineteenth ordinary general meeting of this Company was held on Tuesday at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G., M.P.

The ACTING SECRETARY (Mr. John Cambrook) read the notice convening the meeting, and the minutes of the last ordinary general meeting, which were confirmed.

The CHAIRMAN: Gentlemen, you have had the report in your hands for some days, and I presume you will take it as read; but before asking you to approve of it, I must give you the reasons for the small difference which has taken place in our dividend this half year. As you are aware, we are a Trust Company. We receive dividends from the different companies whose stocks we hold, and we pay out all the money we receive; and our dividend is more or less guided by the prosperity of other companies. Our receipts for the year ended July 18, 1892, show a decrease, as compared with 1891, after payment of expenses, of £9,455. This is to be accounted for from the fact that we have received £2,184 less on our Anglo-American investment; £3,823 less from the Brazilian Submarine Company, and no dividend from the German-Norwegian Company. We have also received somewhat smaller dividends from the West African and the Western and Brazilian Company—together amounting to about £1,000 less this year. Our accounts show, however, that although our revenue for the present year is £9,455 less than last year, the sum we are able to divide is only £7,697 less, owing to the larger balance brought forward in 1891. We have, then, gentlemen, to recommend to-day a dividend of 4⅞ per cent. for the present year. Last year we were able to recommend a dividend of 5¼ per cent. That is to say, we propose now to pay you 9d. less than last year, owing, as has been said, to our having £7,700 less to divide on account of the smaller returns on some of our investments. Our preference and ordinary shares, taken in like quantities, show a return of £5. 8s. 9d. per cent. The money re-invested in the West Coast Company so far has given us no return, but the prospects of dividend from this source are very promising. There is a line now being constructed across the Andes, which will bring the Brazilian Submarine into communication with the Pacific Coast, and we then expect to see a considerable increase of traffic, not only for the Western and Brazilian Company, but also for the West Coast Line. The Brazilian Submarine Company have given us £4,000 less than they did last year. That Company is building up their reserve fund, and we hope they will soon return to their former dividend for the reason I have stated. The present dividend which we receive from that Company shows a return on our investment of over 7 per cent. With regard to the Anglo-American and the Direct Companies, the former pay us 2s. 8d. per cent. less this year. At the last general meeting the prospect was held out of improvement in the dividends paid by these companies, and it was said that reference would be made to them this year. Anyone who reads the papers from day to day will know that there is at the present moment very considerable depression prevailing. Trade is unhinged, and, as you know, we live by trade; but I cannot for a moment believe that this state of things is going to continue very long, and I hope that when better trade prospects come round, there will be better dividends, and we shall get back to our old position as regards these companies. With respect to the Eastern and Extension Companies, we have a large amount of capital invested in them. They show good returns, their yield to us being over 6½ per cent. taken together. Our American Cable shares show a return of 5¾ per cent., and our Western Union shares pay us £5. 17s. 5d. per cent., and have improved in value. Our holdings in the Western and Brazilian and West African Companies have given us 1 per cent. less on each class of shares for the present year as compared with last year, having paid us this year 4 per cent. compared with 5 per cent. last year. We have to announce the decease of our late Secretary, Mr. Payton, who was a good, useful, and confidential servant during a large period of the existence of the Company. He died the other day, and about the same time we also lost one of our Directors, Mr. Ford. We have expressed in our report our regret at losing the services of such a valuable Director. I have very little to say further. The dividend that we are paying you now is smaller than that which we gave you last year, but I have told you the reasons why it is smaller, and I have also given you my belief that with the general growth of telegraphy our dividend will improve; and telegraphy must grow, for it cannot stand still. Our investments in the different companies are large and important, and I think we may say without any hesitation that they are of a very sound and promising nature, and that with good trade we shall have improved dividends. With bad trade we have to take our chance, but our reduction this time is not serious, and it is one which I strongly believe will very soon be recovered. With these remarks I beg to move the following resolution:—

"*That the report and accounts for the year ended July 18, 1892, submitted to this meeting be, and they are hereby, received and adopted, and that a dividend be now declared, payable on and after this day, of 3s. per share on the Preference Shares, less income tax, and of 3s. 9d. per share on the Ordinary Shares (income tax having already been deducted), making, with previous payments, a total dividend for the year of 6 per cent. on the Preference Shares, less income tax, and of 4⅞ per cent. net on the Ordinary Shares.*"

The MARQUIS OF TWEEDDALE seconded the motion.

The resolution was unanimously adopted without discussion.

The MARQUIS OF TWEEDDALE then proposed the re-election of Sir John Pender, K.C.M.G., M.P., as a Director of the Company. He was sure that he need scarcely say a word in support of the resolution. Sir John Pender had been Chairman of the Company from the first, and had presided over their deliberations with eminent ability and success, and he trusted that the shareholders would show their appreciation of the able manner in which he had looked after their interests by giving the resolution their hearty support.

Sir H. D. GOOCH, Bart., seconded the motion, which was unanimously adopted.

The CHAIRMAN, in reply, thanked the shareholders for the unanimous way in which they had re-elected him. He regretted, as he liked to see a large meeting, that their meetings were growing less; but he could only assume, when he looked at the numbers present and remembered that there were 9,000 shareholders in the Company, that while the meetings were growing less, the confidence of the shareholders in their Directors was growing more. The work of the Board was important in its way. They had to watch what other companies were doing. Some of the Directors were largely interested in those companies; and he must say that in their dealings with them he always asked himself what would be the effect on the Globe Company of any given matter affecting their interests. When, for instance, he heard of the alteration the other day in the tariff of the Western and Brazilian Company, he considered how far the reduction would affect the Globe; and it had affected them a little more than he liked. A reduction from 5¼ per cent. to 4⅞ per cent. was not large, but he liked to go forward; and it would be for them to find out whether, by putting a spur into some of the other companies, they could not get back the little they had lost. He again thanked them for re-electing him, and he assured them that it would be his endeavour to increase still further the confidence of the shareholders in their Directors. He afterwards proposed the re-election of Sir James Anderson, and expressed the hope that that gentleman would try and think of some economies, or of something else, which would restore to the shareholders the small loss of dividend sustained by them on the present occasion.

Mr. JAMES PENDER seconded the motion, which was unanimously adopted.

Sir JAMES ANDERSON, in acknowledging the vote, observed that the fact that the Company referred to had paid a lower dividend was not due to the Directors. If a rival company started and lowered the tariff, what could the other Company do?

On the motion of Mr. T. H. HODGSON, seconded by Mr. W. WILD JONES, the auditors, Mr. John G. Griffiths, F.C.A., and Mr. William Griffith, B.A., were re-elected.

Mr. GRIFFITH, in reply, referred to the admirable way in which the books of the Company were kept, and assured them that all their securities were safe, as he had had ocular demonstration of the fact. He afterwards proposed a vote of thanks to the Chairman and Directors. They were most fortunate in being presided over by a gentleman so well versed in telegraphy and so well known throughout the world, and Sir John Pender was ably supported by men of great reputation and of considerable influence.

The motion was seconded and unanimously carried.

The CHAIRMAN, in reply, stated that all the Directors were deeply interested in the concern, and they aimed at performing their duties in such a way as to enable the auditors to make such a declaration as that made by Mr. Griffith that day. They took care that their relations with other companies were right and that the securities in their strong box were sound and secure. They were pleased to find that the shareholders recognised the responsible position occupied by the Board.

The meeting then separated.

United River Plate Telephone Company (Limited).

The sixth annual ordinary general meeting of the Company was held at Winchester House, 50, Old Broad-street, on Tuesday last; Mr. J. Irving Courtenay presiding.

The SECRETARY (Mr. Robert Herring) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: Gentlemen, in moving the adoption of the Directors' report and the balance-sheet I must first point out what an extremely critical period this Company, in common with all other companies in the River Plate, has had to pass through. It has been a crisis that has tested the stability of the soundest undertakings, and no company could stand such a prolonged ordeal unless it was intrinsically sound. Though it may be considered rash to attempt a forecast, still I incline to the opinion that matters (both financial and political) in the River Plate have seen their worst. It would be premature to say that those who are interested in the Argentine Republic are, to use a common expression, "out of the wood;" yet we cannot but hope that the marked improvement in River Plate affairs, which has taken place in the last few months, will continue. We all look forward with confidence to the new Government which will come into power in October next, and that the measures of economy already shadowed forth, aided by careful and prudent administration, will, in time, lift that undoubtedly rich country out of its present unfortunate condition. I would call your special attention to the important fact that the general business in Argentina is steadily improving and confidence is increasing. The recent fall in the gold premium at

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this time of the year should be assisted by the coming harvest. I will now go through the figures in the profit and loss account and balance sheet, and offer such observations and explanations as may seem to be necessary and desirable. The gross income from the River Plate for the period under review was £98,699. 8s., against £106,259. 19s. 8d. in the previous year. This difference is to some extent caused by a falling off in our subscribers between March 31, 1891, and March 31, 1892; but I may say it is mainly due to our writing off over £5,000 for subscriptions which our Buenos Ayres managers have considered is the most prudent course to pursue; but some of these may yet be recovered. Notwithstanding the economies that have been effected, our expenses in the River Plate have slightly increased. Roughly speaking, there is under this head an apparent increase for the year of £2,000. This is the increase at par of exchange, assuming the paper dollar to be worth 4s.; but to get at the actual sterling increase we must deduct the loss on exchange, which amounts to nearly 75 per cent., thus leaving us a sterling increase of a little over £500 only. We have continuously urged upon our representatives in the River Plate the necessity for carrying out all economies they could consistently with an efficient service, and we believe that they have to the best of their judgment given effect to our wishes; but I would remind you that when I addressed you last year I indicated that some increase in the expenses was to be expected. The principal cause for this is the augmented cost of materials and other necessaries requisite for the carrying on of the ordinary business of the Company. Now, as I have opened necessarily this vital question of the loss on exchange, you will see by referring to the profit and loss account that this loss for the year ending March 31st last is £31,741. 0s. 8d., an amount nearly representing 11 per cent. on the Company's paid-up share capital. You will remember that we had quite a discussion last year upon this same subject; still, I should like again to make you all understand how this exchange figure is arrived at. You will notice that the gross receipts amounted to, say, £98,700, and the whole of our expenditure in the River Plate was in round figures £58,600, thus leaving a profit in paper dollars, the par value of which is £40,100. We are compelled to remit this profit home to pay debenture interest and other expenses in sterling, and in so doing we lose on exchange £31,700, which leaves us a balance when received in London of £8,400 to meet these expenses. In the London expenses we have made a considerable reduction. They stand at £1,838. 2s. 5d., against £2,732. 14s. 9d. for the previous year. Referring to the statement in the Directors' report that since March last the business of the Company has improved in sympathy with the better condition of affairs in the Argentine Republic, and that therefore we think the working for the current year will be much more satisfactory than has been the result of the last year, I will now give you shortly the reasons why we entertain this belief. Firstly, we have a substantial increase in the number of subscribers; then the gold premium has fallen from an average of 280 per cent., to, say, 223 per cent, and I may remind you that during the year it went as high as 365 per cent.; again, it is important to note that there is no proportionate increase in the working expenses on account of the additional number of subscribers, and they have been added to our list at a minimum expense so far as capital outlay is concerned. The shareholders will notice that the capital outlay for the year has been extremely small—£1,003. 18s.—but you must not infer from the smallness of this outlay and the absence of any further addition to the depreciation and renewal fund (which now stands at £9,000) that our plant has not been kept up to its usual high state of efficiency. Our managers in Buenos Ayres and Rosario write us that the whole of it is in first-class condition, and that our service continues to give every satisfaction. We have spent a considerable sum at Buenos Ayres which is charged to revenue, for building new structures, putting up posts, trunk and other lines; and at Rosario, in consequence of the introduction of the electric light, special appliances have been provided to guard against any damage resulting from contacts. We are very much indebted to our representatives in the River Plate, Messrs. Fells and Krabbé, and also to our efficient managers, Messrs. Chappell and Parker, for the very excellent manner in which they have protected the interests of the Company during the exceptionally trying period of the past two years. Some of the shareholders may wish for further information, which, if in our power, we shall be happy to furnish. I now beg to move: —

"*That the report and accounts submitted to the meeting, be, and they are hereby, received and adopted by the Company.*"

Mr. FRANK W. JONES seconded the motion.

Mr. LAWRENCE said that if he gathered the remarks of the Chairman rightly, £40,000 odd was remitted home and produced only £8,400 sterling. This surely must be owing to the unfortunate time at which the money was sent home.

The CHAIRMAN replied that the money is sent home at fixed intervals.

Mr. LAWRENCE asked for information concerning an item in the balance-sheet of nearly £30,000 for conversion of debentures and issue of stock. He would further like to ask whether nothing could be done to increase their receipts in Argentina by way of raising the charges to their customers? It was rather hard to supply telephonic communication in Buenos Ayres at the expense of the English shareholder.

A SHAREHOLDER asked what were the shares of the Province of Buenos Ayres Telephone Company?

The CHAIRMAN: This item has been fully explained at previous meetings. It resulted from our having to convert 7 per cent. debentures at a high premium to 5 per cent. debenture stock. They certainly had power to raise their charges to their customers; but there was a limit beyond which they could not go, and that limit they had reached the last time the charges were increased. The shares in the Province of Buenos Ayres Company were taken in lieu of a bad debt, and were fairly valued at the amount appearing in the balance-sheet. That Company's business was improving.

The motion was then put and carried unanimously.

The CHAIRMAN next proposed the re election of Messrs. George Cooper and Alfred Le Rossignol to their seats at the Board.

The motion was duly seconded by Mr. Billeter and agreed to.

The Company's auditors, Messrs. Cooper Brothers and Co., on the motion of Mr. R. E. BATEMAN, seconded by Mr. J. R. BAILLIE, having been reappointed,

Mr. LAWRENCE proposed a vote of thanks to the Chairman and Directors, which Mr. COURTENAY acknowledged; and the proceedings terminated.

City and South London Railway Company.

The following is the report of the Directors, to be submitted to the half-yearly ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Friday next, August 5th, at 3 o'clock p.m.: —

The receipts during the half-year from all sources amounted to £21,520. 4s. 8d., and the cost of working for that period to £15,097. 13s. 2d., leaving a profit of £6,422. 11s. 6d. Inclusive of the balance brought forward from last year, the net revenue account shows a total of £7 348. 19s. 9d. After providing the debenture interest, amounting to £4,317. 7s. 4d., there remains a balance available for dividend of £3,031. 12s. 5d., out of which your Directors recommend that the full dividend of 5 per cent. per annum be paid on the Perpetual Preference Shares, and they further recommend that a dividend at the rate of ½ per cent. per annum be paid on the ordinary shares, leaving a balance of £183. 2s. 2d. to be carried forward to next account.

The number of passengers carried by the railway during the six months, exclusive of season ticket holders, was 2,813,162, showing an increase over the corresponding period last year of 400,819.

The steady decrease in the expenditure alluded to in previous reports has been satisfactorily maintained, notwithstanding a considerable further increase in the amount paid for rates and taxes.

The rolling stock and plant have been efficiently maintained and are in good working order. The fourth generating engine and dynamo are erected and ready for use. Arrangements have recently been made by which the public are allowed to view the generating station on payment of a small charge, and this privilege is being availed of to a considerable extent.

During the past Session a joint committee of the two Houses of Parliament was appointed to consider and report upon the best method of dealing with the various electric and cable railway schemes in the metropolis proposed to be sanctioned by Parliament. They reported strongly in favour of electricity as a motive power, and made some valuable suggestions for the extension of railways of this character. The successful working of this line had no doubt much influence in inducing the committee to make so favourable a report.

Owing to the Dissolution of Parliament the Bill promoted by this Company for the extension to Islington and other purposes could not be proceeded with further than the Second Reading in the House of Commons. Your Directors therefore decided to take advantage of the resolution passed by both Houses by which all private Bills are carried over to next Session, when they will be proceeded with at their present stage.

The urgent need of additional siding accommodation at Stockwell Station to meet the requirements of growing traffic renders it desirable that this work should no longer be delayed. To meet this expenditure it will be necessary to issue some additional preference shares. A resolution to that effect will be submitted at the special meeting.

Your Directors being of opinion that the time has now arrived when the present terminable Debenture Mortgage Bonds should be converted into Perpetual Debenture Stock, propose to ask the shareholders for authority to carry this out; and a resolution will be submitted at the special meeting for the creation and issue of Debenture Stock to the extent of the authorised borrowing powers of the Company. It is hoped that a considerable saving in the interest charges will be effected by this operation.

Your Directors have to announce with great regret the death of Major Kitson, who has been one of the auditors since the commencement of the railway. Notice has been received from a large shareholder of his intention to propose Mr. James Lorimer Oliver to fill the vacancy thus created.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

AMERICAN INSULATED WIRE COMPANY (LIMITED).—This Company was registered on the 21st inst., with a capital of £75,000, in £5 shares. The objects are to apply for, purchase or otherwise acquire any British or foreign patents, brevets d'invention, licences, concessions, &c., conferring an exclusive or non-exclusive or limited right to use any inventions capable of being used in the manufacture of wire, wire ropes and cables for electric purposes; to use, work, exercise, develop, sell, grant licences in respect of or otherwise turn to account any such British or foreign patents, and to carry on in the United Kingdom or America or elsewhere the businesses of manufacturers of and dealers in wire, wire ropes, and cables of all kinds, founders, machine makers, mechanical and electrical engineers, electricians, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all apparatus required for

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er capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The subscribers (with one share each) are:—Charles G. T. Neumann, Forster-square, Bradford; J. B. Atherton, Rainhill; William M. Brigg, Hawkstone, Keighley; Herman Neumann, 13, Claremont, Bradford; J. Atherton, Huyton; Hugh M. Brigg, Hawkstone, Keighley; Frank J. Leslie, 15, Union-court, Liverpool.

ANDREW BARCLAY, SONS AND CO. (LIMITED).—This Company has been formed, with a capital of £15,000, to carry out agreements with Andrew Barclay, Son, and Co., engineers, Kilmarnock; Thomas Steven, ironfounder, Glasgow; and Joseph Reid, iron merchant, Glasgow; to carry on the business of engineers, ironfounders, boiler-makers, locomotive engine makers, &c., in continuation and extension of the present business of Andrew Barclay, Sons, and Co.

REGENT GOLD EXTRACTING COMPANY (LIMITED).—This Company has been formed, with a capital of £3,000, in £1 shares, to acquire the patents relating to the extraction of metals from ore granted to John E. Chister, to obtain and work mines, ores, and minerals, to operate on ores and minerals, and obtain gold and other metals therefrom. The first subscribers include J. T. Bottomley, 13, University-gardens, Glasgow, and William F. King, electrical engineer, Edinburgh.

ROOTS' PETROLEUM MOTOR SYNDICATE (LIMITED).—This Company was registered on the 22nd inst., with a capital of £2,000, in £1 shares. The objects are to acquire from James D. Roots an invention in respect of which letters patent have from time to time been granted for the United Kingdom and the Isle of Man, and also certain rights acquired conferring protection in France, Belgium, Germany, Austria, Italy, Spain, and the United States of America, and to develop and turn to account the same.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to May 26th, was filed on the 20th inst. The Company was registered on November 18, 1884, with a capital of £100,500, divided into 20,000 ordinary shares of £5 each and 500 founders' shares of £1 each. At the time of making up 9,277 ordinary and 500 founders' shares had been taken up, of which the founders' shares had been issued as fully paid, and of which 5,666 ordinary shares had been issued in payment of contracts for plant supplied and erected. Upon the remaining 3,611 ordinary the full amount had been called, and all calls (£18,055) paid.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.—The annual return of this Company, now in voluntary liquidation, on account of sale of business to National Telephone Company, made up to June 22nd, was filed on the 22nd inst. The Company was registered on December 17, 1884, with a capital of £400,000, divided into 20,000 preference shares of £5 each, and 300,000 ordinary shares of £1 each. At the time of making up all the preference and 281,197 ordinary shares had been taken up, of which 3,400 preference and 281,197 ordinary shares had been issued as fully paid. Upon the remaining 16,600 preference shares the full amount had been called, and the calls paid (including £10 which had been paid on 20 forfeited shares) amounted to £83,010.

CITY NOTES, &c.

CALLS DUE.—*Aug. 2nd:* 15s. (final) on 60,000 Ten per Cent. Preference Shares of ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED). *Aug. 20th:* £25 per cent. (final) on £10,000 Five per Cent. First Mortgage Debentures of the EXETER ELECTRIC LIGHT COMPANY (LIMITED). *Aug. 31st:* £1 on 45,000 £5 shares of the ISLINGTON AND GENERAL ELECTRIC SUPPLY (LIMITED).

CENTRAL AND SOUTH AMERICAN COMPANY.—This Company has declared a quarterly dividend of 1¾ per cent. The Company has a surplus of about $297,517, and now has 7,100 miles of cable between Galveston, Texas, and Buenos Ayres.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 24th were £788, as against £686 for the corresponding period of last year, being an increase of £102. The total receipts for half-year amount to £3,049, against £2,785 in the corresponding period of 1891, being an increase of £264. The Directors' report will be found in another column.

DIRECT SPANISH TELEGRAPH COMPANY.—The Directors recommend dividends at the rate of 10 per cent. per annum on the preference shares, and 4 per cent. per annum (free of income-tax) on the ordinary shares, for the half-year ended June 30th.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupons on their Five per Cent. Debentures, due the 2nd prox., will be paid on and after that date at the banking house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment, by warrants on the 2nd prox., of interest for the half year ending the 31st July, on their Four per Cent. Mortgage Debentures. The transfer books will be closed from the 28th inst. to 2nd August, both days inclusive.

ELECTRICAL COAL-CUTTING CONTRACT CORPORATION.—We are informed that letters of allotment in this Corporation have been posted. The prospectus was privately issued.

ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED).—The Stock Exchange Committee have ordered the additional shares No. 70,001 to 82,395 to be quoted in the Official List.

INTERNATIONAL ELEKTRICITATS GESELLSCHAFT (VIENNA).—At the second general meeting, recently held, it was announced that a profit of £17,694 had resulted from the working of the past year.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—At a special general meeting recently held it was decided to rescind the resolution passed in February, to issue £75,000 debenture stock, and instead to issue £125,000 debentures.

MEXICAN TELEGRAPH COMPANY.—Advices from Mexico, dated July 9th, report that the receipts of this Company for the three months ended June 30th were $82,731, and the operating charges $17,500, leaving a balance of $65,231. A dividend of 2½ per cent. for the quarter is declared, which absorbs $47,815, leaving a balance of $17,416, which, added to the surplus after payment of the April dividend, gives a total surplus in hand of $264,180. The Chairman of the Company stated that over 45 per cent. of the Company's business is derived from connection with the Central and South American Telegraph Company. The latter company intends, it is stated, to duplicate the cable between Salina Cruz, on the west coast of Mexico, and Chorrillos, in Peru, at a cost estimated not to exceed $1,500,000. The Mexican Telegraph Company contracts to pay the Company $20,000 per year for three years from completion of the duplicate cable. English contractors will perform the work.

NATIONAL TELEPHONE COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to appoint a special settling day in and to grant a quotation to a further issue of £56,477 Four and a-Half per Cent. Debenture Stock of this Company.

NEW TELEPHONE COMPANY (LIMITED).—The prospectus is issued, and will be found elsewhere in our columns, of the New Telephone Company (Limited), with a nominal capital of £750,000, divided into 74,700 ordinary shares of £10 each, and 3,000 founders' shares of £1 each; the latter are not entitled to dividend until after £7 per cent. is paid on the ordinary shares. The present issue is for the balance of 73,200 shares, of which the National Telephone Company subscribe for one-third (the largest number allowed by the Stock Exchange rules). The issue is made by Messrs. N. M. Rothschild and Sons, and on the £10 shares the following amounts are payable—viz., £1 on application, £1 on allotment, £2 three months after allotment, and the balance (in amounts not to exceed £2) as required, with intervals of not less than four months between each call. As will be seen the Board of Directors includes no less than four gentlemen associated with the National Telephone Company, and we are pleased to see that the threatened opposition to the existing Company takes the form of a working arrangement, from which we think the telephoning public should benefit. There is nothing to interfere with the prosperity of the New Company under the altered conditions, unless it be a difficulty in obtaining the 10,000 subscribers which the Directors consider essential to the success of the undertaking. It remains to be seen whether the National Company have failed in the past to obtain a large proportion of the would be telephoning public as subscribers to their system. The agreement between the New Company and the National Company is in the nature of a working arrangement, by which the subscribers to the New Company will be able to communicate through both systems, and *vice versâ*; and one of the chief objects of the two companies will be (the prospectus states) to work in harmony with the new policy adopted by Sir James Fergusson, M.P., as representing Her Majesty's Government. Intending subscribers to the new Company will have the advantage of the double-wire (metallic circuit) system; and all substantial improvements which experience has proved to be essential to the proper conduct of the telephone system in London will be adopted by the new company, which, as our readers are aware, has already as a going concern the Manchester and Bolton exchanges. The necessary outlay for 10,000 subscribers in London, and upwards of that number in the Provinces, have been carefully prepared and considered by Mr. A. R. Bennett, the chief engineer and general manager of the new Company, whose figures have been checked and approved by Prof. S. P. Thompson and Prof. A. B. W. Kennedy. From these estimates it is calculated that the £750,000 capital will suffice for the introduction of the various improvements in the telephone service. The subscription list opened this day (Friday) and closes at or before four o'clock on the same day.

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—The Directors last week declared an interim dividend for the half-year ended June 30th, at the rate of 5 per cent. per annum, which is the same as last year.

SOCIETE FRANCAISE DES TELEGRAPHES SOUS-MARINS.—The report submitted to the shareholders at the recent annual general meeting showed that the total receipts during 1891 were fr.1,514,499.32, and the expenses fr.818,057.89, leaving a profit of fr 696,441.13. The traffic and subsidy receipts were fr.882,375, an increase of fr.308,763 over those of 1890. A dividend of fr.22.91 per share was declared, and fr.167,056 were carried forward. The Directors stated that obstacles had arisen to the proposal to connect their cable with that of the Société Française du Télégraphie de Paris à New York; but a difficulty which had arisen with the Haytian Government respecting a land line had been removed, and the Company had obtained a 40 years' concession and the exclusive right to land submarine cables.

SOCIETE GENERALE DES TELEPHONES.—A dividend of 20fr. per share has been declared for 1891.

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TELEPHONE COMPANY OF AUSTRIA (LIMITED).—The ninth ordinary general meeting of this Company, which was announced to be held yesterday afternoon, had to be adjourned *sine die*, owing to the absence of a quorum.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—Coupon No. 4 of the Five per Cent. First Mortgage Debentures, due July 31st, will be paid from that date upon presentation to the Consolidated Bank, 52, Threadneedle-street, E.C., or at the banking house of Messrs. Westendorp and Co., Amsterdam.

WEST AFRICAN TELEGRAPH COMPANY (LIMITED).—Notice is given that 103 £100 Five per Cent. Mortgage Debentures of this Company were drawn on Friday for repayment at par on September 1st at the National Bank of Scotland (Limited), Nicholas-lane, Lombard-street, E.C. Other particulars will be found in our advertisement columns.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 24, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,948.

WIENER ELEKTRICITATS GESELLSCHAFT.—This Company is increasing its capital to £300,000.

WIENER PRIVAT TELEGRAFEN GESELLSCHAFT.—There was a profit on last year's working of £17,708, and a dividend has been declared of 8 per cent. The business is about to be taken over by the Government.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. July 20.		Price Wednesday, July 27.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 27.	
										Highest.	Lowest.
			TELEGRAPHS					£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	48	49	48½	49½	5 7 1	Jan., Apr., July, Oct.	48	..
£2,876,140	Stock	25/0	Do. Preferred	88	89	88½	89½	5 17 4	" "	91	88½
£2,876,140	Stock	5/0	Do. Deferred	10½	11	11	11½	..	" "	10½	10½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	103	99	103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½	10¾	10½	10¾	6 10 3	Mar., June, Oct., Dec.	10¾	10⅞
£68,200	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	$1⅜	Commercial Cable Capital Stock	155	160	160	165	4 4 10	Jan., Apr., July, Oct.	160	..
16,000	10	8/0	Cuba Submarine	11	12	11	12	6 13 4	February and August	11¾	11½
6,000	10	10%	Do. Preference 10%	16½	17½	17	18	5 11 1	" "	17½	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3¾	3½	3¾	4 16 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½	11¾	11½	11¾	5 19 2	Jan., Apr., July, Oct	11½	..
400,000	10	2/6	Eastern	14⅝	15⅛	15	15½	4 5 3	" "	15½	15
70,000	10	6%	Do. 6 per Cent. Preference	15½	16	15½	16	3 15 0	" "	15⅞	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108	111	108	111	3 12 1	May and November	110¾	109
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	109½	109
250,000	10	2/6	Eastern Extension	14⅞	15⅛	15	15½	4 12 7	Jan., Apr., July, Oct.	15⅞	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 1	February & August	111	110½
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101	104	101	104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102	105	102	105	3 16 2	February & August	..	..
180,227	10	2/6	Globe Telegraph and Trust	10½	10⅝	10½	10⅝	5 1 2	Jan., Apr., July, Oct.	10⅝	10⅞
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 18 1	" "	15⅝	15⅞
150,000	10	5/0	Great Northern	18½	19	18½	19	4 9 6	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	..	..
17,000	25	1⅜	Indo-European	40	42	40	42	5 19 1	May and November	..	..
35,348	10	4/0	London Platino-Brazilian	6	7	6	7	5 11 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 9 1	March & September	..	..
10,802	8	8/0	Reuter's	7	8	7	8	5 0 0	April and October..	..	..
3,381	£100 Cert.	£1½	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	118½	..
15,609	10	3/0	West African Telegraph	6	8	6	8	5 0 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	101¾	101
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	5 11 1	January and July ..	3⅞	..
£150,000	100	8%	Do. Debentures 8% 1902	101	105	101	105	7 12 5	June and December	101	102½
88,321	10	6d.	West India and Panama	1½	1⅝	1½	1⅝	..	" "	1½	1⅝
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½	10	9½	9¾	6 3 1	May and November	9⅞	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8	9	8	9	6 13 4	" "	8½	8½
64,242	15	6/0	Western and Brazilian	8¾	9⅛	8¾	9⅛	6 9 7	" "	8⅛	8⅝
33,129	7½	1/3	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 7	" "	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾	3¼	2¾	3¼	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105	108	105	108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	105	108	105	108	5 11 1	" "	107½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
124,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛	⅜	⅛	⅜	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	1/16	5/16	⅛	¼	7 18 2	Yearly	..	..
438,984	5	2/6	National	4⅝	5⅛	5	5½	5 14 3	June and December	5⅛	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13¾	14¼	13¾	14¼	4 4 3	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13	13½	13½	13¾	4 7 3	" "	13½	13⅞
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109	111	109	111	4 1 1	January and July ..	110½	110
58,000	5	1/0	United River Plate	1½	2½	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	—	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	9¼	10¼	9¼	10¼	..	—	10½	10⅛
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	2½	3½	..	..	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5	5½	..	..	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½	5¾	..	..	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 1/16	3 1/16	3 1/16	3 1/16	..	March	..	..
10,030	£5	4½%	Do. (fully paid)	5 1/16	5 1/16	5 1/16	5 1/16	..	March	..	..
111,000	5	..	London Electric Supply	¾	1	..	..	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾	7¼	6¾	7¼	..	—	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4	5	4	5	—	—	..	..
18,680	£5	5/0	St. James' and Pall Mall	7¾	8¼	7½	8	—	..	7⅞	7⅞
7,900	£5	7%	Do. 7% Preference	7¾	8¼	7¾	8¼	..	..	8	..
42,853	5	..	Westminster Electric Supply (fully paid)	5½	6	5¾	6¼	..	..	6¼	5¾
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	2⅞	3⅛	2⅞	3⅛	..	..	2⅞	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2⅛	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	6	5½	6	5 16 8	January and July ..	..	..
12,139	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	4¾	5¼	4¾	5¼	..	—	..	4¾
70,000	2	10/0	Elmore's Patent Copper Depositing	2	2¼	2⅛	2⅜	—	—	2⅛	2¼
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works xd	20½	21½	20½	21½	5 16 3	February & August	21	20¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104	106	104	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½	4½	3½	4½	..	..	..	..
11,334	£10	8/0	Do. Preference	6	7	6	7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼	1/16	¼	5/16	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3	3½	3	3½	11 0 0	May and November	3⅜	3⅛
37,350	12	12/0	Telegraph Construction and Maintenance xd	44	46	44	46	5 4 6	March and July	45½	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103	106	103	106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½	¾	..	..	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½	3	..	..	..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	..	..	..	..
50,000	£10	..	City and South London Railway	2½	3½	2½	3½	—	..	..	..

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THE ELECTRICIAN:

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NOTES.

The sixty-second meeting of the British Association was opened on Wednesday last by a lengthy address on the "Geological History of the World," by Sir Archibald Geikie; and the sectional meetings were in full swing yesterday, when Prof. Schuster delivered his presidential address in Section A, and Prof. Unwin in Section G dealt with the history of the steam-engine and the distribution of power. Prof. Schuster's address was of a less practical, though of a more generally interesting character than Prof. Unwin's; solar physics, electric discharges in gases, magnetic theories and educational problems being touched on in succession. Prof. George Forbes read a Paper in Section G on "The Application of Destructors to the Electric Lighting of Edinburgh;" and in Section B, Prof. Crum-Brown read a Paper on "Electrolytic Synthesis."

Three courses are generally open to those upon whom devolves the duty of delivering presidential addresses before scientific societies: they may either review the progress of a particular branch of knowledge during the last fifty years; or, if specialists, they may confine themselves to a description of the work in which they themselves are engaged; or they may discuss some more general but definite subject. We have had rather too many *résumés* of late, and though they may interest the general public, they must be very well done to be attractive to those who take an intelligent interest in scientific matters. The pure specialist is, no doubt, well advised in sticking to his own hobby on these as well as on other occasions; but it would perhaps be well if both presidential addresses and more of the Papers read before the Sections dealt with wider subjects, instead of being based, as they too frequently are, on scrappy notes which the authors would hesitate to present to any other scientific society.

In a Paper "On Transformers," the first portion of which we print in the present issue, Herr Dolivo-Dobrowolsky refers to the loss of power in iron cores due to hysteresis. This well-known engineer states that, as regards the dependence of the core losses on the intensity of the magnetism, the result of his experience is to closely confirm the law recently given in these columns by Mr. Steinmetz, viz., that the core losses are proportional to the 1·6 power of the density of the lines of force. He, however, makes the important remark that the actual amount of hysteresis waste in ordinary transformers is considerably greater than Ewing's numbers would indicate. From two years' tests made on a great number of samples of sheet iron, he finds that, for good medium iron, Ewing's figures should, in general practice, be multiplied by 1·6 or 1·7. The hysteresis losses occurring in transformers are so much greater than any others, that the correctness of this statement is an important question. Ewing's numbers, it is true, were not obtained with alternating currents, but they have been reinvestigated by Messrs. Evershed and Vignoles, and also by Mr. Steinmetz. The values found by these gentlemen were in all cases slightly higher than those of Prof. Ewing; but the differences obtained were small. An increase of 70 per cent., such as Herr Dobrowolsky finds, seems unlikely; and although the iron is said to have been well laminated, we are inclined to attribute much of the extra loss to eddy currents.

In discussing the relative merits of the various forms of magnetic circuit used in transformers Herr Dobrowolsky acknowledges the importance of Mr. Swinburne's work, and, although not endorsing all his conclusions, agrees with him in several important points. The old idea that the iron circuit should be massive and free from joints is shown to be misleading, long thin cores, which allow plenty of room for the copper, being preferable. Also, instead of attempting to save copper by enclosing it as far as possible with iron, the aim should rather be to save iron by surrounding it with copper. In fact, the idea of reducing the copper losses is delusive, not only because the greater losses occurring in the iron renders this saving unimportant, but also because the regulation for different loads so secured is apparent and not real, since the drop of volts caused by the resistance of the leads is disregarded. Herr Dobrowolsky does not advocate the open magnetic circuit, but shows that it is possible by attention to these principles to design transformers of the closed-circuit type with an all-day efficiency of over 90 per cent. This excellent result is obtained by allowing from 5 to 6 per cent. of the output at full load to be lost in the copper, an amount which is in excess of the usual English practice. The recent tests of Westinghouse transformers by Dr. Hopkinson show, however, that it is possible to design closed-circuit transformers with a higher all-day efficiency than 90 per cent., with a smaller loss in the copper, and thus without any serious drop of volts due to the resistance of the coils.

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The correctness of the objections raised by Messrs. Kelly and Steinmetz to the claims made in favour of the polyphase motor depends more upon the nature of the assumptions made than upon the truth of the reasoning. It will be seen, from the abstract of the discussion which we print elsewhere, that it is quite possible for two sine currents, differing in phase by a quarter of a period, to supply energy at a constant rate; and Herr Dobrowolsky's conclusions in this respect appear to require modification. But the practical question is whether the rotating field obtained with three-phase currents is more constant in strength than when two-phase currents are used. The arguments of Mr. Steinmetz would be more applicable if each coil traversed by the current consisted of a single turn, instead of several, occupying an appreciable portion of the circumference, and if the coils were wound on a drum armature instead of on a Gramme ring. When wound as usual in the latter fashion, the magnetomotive forces due to the differently phased currents in the coils add up in the same way as the electromotive forces in the coils wound round the semicircumference of a Gramme ring. In a dynamo the greater the number of commutator sections, the more constant is the voltage of the machine, and similarly in a polyphase motor the greater the number of phases the more constant is the strength of the rotating magnetic field. While the brush of a dynamo is moving over the bar of a commutator the position of the coils, with reference to the external circuit, is unaltered electrically, and the connection between them is not altered continuously, but by intermittent changes. Similarly while the direction of the resultant field in a polyphase motor is sweeping over one of the coils, the currents in the two parts of this coil are oppositely directed as regards the magnetic circuit, and do not produce the requisite magnetising force to keep the field constant.

The shape of alternate-current curves has formed the subject of several researches, notably of some by Messrs. Ryan and Merritt, who succeeded in showing that these curves are made up by combining a simple sine curve with others whose periods are odd multiples of the period of the principal wave. These harmonics have generally been attributed to hysteresis; but Prof. Rowland, in a brief note on transformers contributed to the current issue of the *Philosophical Magazine*, shows that they may be perfectly accounted for as a consequence of the fact that the permeability of the iron varies with the strength of the magnetising force. It is also shown that the effect of hysteresis is equivalent to increasing the resistance of the coils, and that the importance of the harmonics becomes greater as the magnetism of the core increases. Prof. Rowland's conclusion that the harmonics are due simply to variable permeability and do not depend on hysteresis seems, however, to need confirmation, since the line of argument used appears as well adapted to show that the effects are due to hysteresis as to changes in permeability.

The French are a logical people, and some of them are beginning to ask why trading and commercial telegrams are charged at higher rates than press telegrams. Journalism—or rather the conduct of journals—is a trade, pursued with the same objects as every other business, and therefore entitled to no special privilege not enjoyed by the trading community. We quite agree with the reasoning, but our conclusion would be different. Remove the inequality by all means, but begin with the press. The only excuse that we can see for its special privileges is the same as that which accounts for our giving a cabman fifty per cent. more than his fare—because he would bully us frightfully if we didn't. As to the argument that the national revenue would be benefited by an extension of press rates to business firms, one may reasonably ask why not also to private families? To leave them outside the privileged circle would be to make them pay for the deficiency created by special tariffs; and to include them in that circle would be to extinguish privilege altogether. Probably the French Deputies will see the matter in that light before they have done with it.

Free-Trade in glow-lamps, like free-trade in other commodities, will not prove an unalloyed blessing if we may judge from the state of things which obtains in Germany at the present moment. Our German correspondent reports this week that the price of the best make of 16-c.p. lamps has recently been reduced from 1s. 6d. to 1s. This sudden move has apparently exasperated the smaller manufacturers, and they are now bewildering the unfortunate consumer with a shower of pamphlets which fill his mind with visions of 1½-watt lamps, and make no mention of life or of constancy of candle-power, points with respect to which the leading makers have something to say in a warning circular which they have found it necessary to issue. In this country glow-lamps are discreetly sold without any guarantee as to life, constancy or efficiency; but when the free-trade era commences, rival makers will in all probability be driven by stress of competition from this nonchalant attitude, and a plentiful crop of litigation may be expected to follow.

Eccles.—The Local Board has decided to apply for an Electric Lighting Order.

Hammersmith Vestry.—This Vestry has decided to apply for an Electric Lighting Order.

Brussels.—The final settlement of the electric lighting question is deferred for another three months.

Canadian Patent Law.—The Dominion Senate has passed a Bill to amend the Patent Act, extending the life of a patent from 15 to 18 years, and doing away with the necessity of models.

Owens College, Manchester.—A special course has been arranged at this College on the technical applications of electricity. For further particulars see our advertisement columns.

Electric Launches.—The Westminster Yachting Association have organised a daily excursion by road and river. A coach runs from the Grand Hotel to Kingston, where passengers embark on the electric launch "Omicron," for Chertsey.

Chicago Exhibition.—With regard to the rumour which has been pretty generally circulated that the Chicago Exhibition Executive was bankrupt, it is stated that the fact is the Exhibition has now $2,500,000 cash in bank, and about a million more in sight.

Telegraphy in West Africa.—The German Postal authorities are said to be making inquiries of several telegraph engineers whether they would be willing to set up a system of telegraph lines in West Africa, particularly in the German dependencies of the Cameroons and Togo.

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Copper.—According to Messrs. R. Merton and Co. the stock of copper in England and France and afloat thereto amounted at the end of July to 59,738 tons, as against 57,782 tons at the end of July, 1891. The average price of Chili bars was £44. 17s. 6d. during July last, and £52 during the same month of 1891.

Personal.—Mr. H. B. Bourne has been appointed electrical engineer to the International Okonite Company as regards their contract for laying mains in Manchester.—The Corporation of Blackpool have selected Mr. John Hesketh, of the Newcastle-on-Tyne Electric Supply Company, for the appointment of electrical engineer to that borough.

Bedford.—At a special meeting of the Town Council, held on Monday last week, a communication from the Bedford Electric Light Company was considered. After a lengthy discussion it was formally resolved that the Board of Trade should be informed that negotiations were now pending with a view to the transfer of the powers of the Order of 1890, and that the application of the Bedford Electric Light and other companies should be considered.

Appointments in Cable Companies.—The following appointments have been made:—Mr. G. R. Neilson, to be assistant secretary of the Eastern Telegraph Company (Limited); Mr. Sidney Collet, to be secretary of the Globe Telegraph and Trust Company (Limited); Mr. John Cambrook, secretary of the West African Telegraph Company (Limited); and the Hon. A. G. Brodrick, secretary of the Submarine Cables Trust. These changes are consequent upon the death of Mr. William Payton, late secretary of the three last named companies.

International Exhibitors' Association.—We have received a pamphlet relating to this Association, which has been formed in New York by merchants who expect to exhibit at Chicago. The Association, it is stated, has been formed for obtaining privileges and effecting economies. It is expected that by this co-operative work exhibitors will be able to make a considerable saving. The Association proposes to assist its members both in getting their goods to Chicago, installing them, and looking after them. The head office of the association is in the Stewart Building, New York, and the membership fee is $25.

Earth Currents.—The following extract from a letter from Aden station, dated July 21, 1892, will be read with interest in connection with the remarks on the same subject which will be found elsewhere in the present issue:—

"On Saturday, 16th instant, there were indications of a strong magnetic storm. It was felt on all circuits, and caused the recorder syphons to go off paper from one side to the other, somewhat interfering with the traffic. It lasted from about 6:30 p.m. until 9 p.m. We were afraid of delaying the work, otherwise it would have been interesting to have taken more observations. As it was we observed Suez No. 2 on the galvanometer for a few minutes (that cable being clear at the time), and found the maximum earth-current equal to 52 volts negative. It was probably more on the other cables. On Zanzibar section it was especially marked."

Taunton.—On Monday last week a special meeting of the Town Council was held for the purpose of considering the proposal to purchase the electric light works. The Electric Lighting Committee presented a report in which they recommended that the amount necessary be raised by borrowing for a period of 50 years, or such other period as the Local Government Board would grant. The amount which it is proposed to expend is £14,000. Of this £9,300 will be devoted to the purchase of the works, while £1,900 will be expended in the substitution of underground for overhead wires; £1,000 of the total will be set apart as working capital. The Council by eleven votes to three adopted this report.

Electrical Communication with Lighthouses.—At a recent meeting of the Cardiff Health and Port Sanitary Committee a letter was read from Mr. J. Gavey, superintending engineer of the Post Office Telegraph Department in South Wales, stating that the department were about to make certain experiments with a view of ascertaining how far it may be possible to establish electrical communication with outlying lighthouses, without the necessity for laying special submarine cables, and stating that it was desirable such experiments should be made, if possible, between the mainland near Lavernock and the Flat Holms. In order to facilitate this public work, he asked permission for himself and his staff to land at the Flat Holms, and lay temporary wires across the island with a view of thoroughly testing the feasibility of the proposal. It was unanimously agreed to grant the permission asked.

The New Telephone Company.—The following extracts from a leading article which appeared in the *Economist* of July 30th will secure the attention to which the remarks of this financial journal are always entitled:—

"The promoters of the New Telephone Company, who during the past week invited subscriptions for £488,000, part of an authorised capital of £750,000, have displayed a considerable amount of prudent forethought in securing the services of Messrs. N. M. Rothschild and Sons as their issuing agents; for although the new departures made by that firm in recent years have sometimes seemed to old-fashioned people somewhat venturesome, the reputation of the great financial establishment still stands high among the investing classes of the country. We cannot believe, however, that their reputation will be enhanced by their connection with this telephone company. . . . . The fact that the National Telephone Company is to subscribe for one-third of the capital of the New Company, and has nominated one-half of the Board of the undertaking, including its own president and vice-president, is made the most of in the prospectus; but the arrangement does not seem to us an advantageous one to the New Company, to say nothing of the requirements of the public. . . . It is desirable, of course, that the interchange of means of communication should be made as perfect as possible; but the connection between the two companies is obviously intended to stifle competition, and thus prevent such a lowering of the charges as the public have a right to demand, seeing that the companies are to have a sort of copartnership with the Post Office. . . . . It is indisputable that the telephone service forms part and parcel of the telegraph monopoly owned by the State; and those who are responsible to the public would perform their duties in a very lax manner if they permitted the exaction of charges which must inevitably retard the development of the telephone industry, and thus render the Governmental portion of the business less remunerative than it should be."

Dublin.—On Friday last the report of the Electric Lighting Committee came up for adoption by the Town Council at a special meeting. The following resolution was carried unanimously:—"That the report be adopted with this exception, that the Committee shall not be compelled to enter into any contract with the Messrs. Hammond and Co., but shall have power if they see fit to enter into a contract to run the station and plant and any extension of same for one year with either Messrs. Hammond and Co., or, if they see fit, may undertake and carry out the running of the station themselves, employ workmen, purchase materials, and do all necessary acts in the matter." It was intimated to the meeting that a notice had been received from the contractors, Messrs. Hammond and Co., that they would contest the right of the Corporation to take the contract for twelve months from them and give it to any other firm. The report stated that, owing to some of the electric light customers being in urgent need of current, it was absolutely necessary that the Committee should be given plenary powers with regard to making arrangements for running the station.—It appears from an article by Mr. A. Fahie in the *Health Record* that the Corporation propose to charge 8d. per unit for any quantity up to 100 units, and above that amount 7d. per unit. A minimum of £2 per quarter is proposed, as well as rent for transformer, which varies from 5s. to £2 per quarter, and rent of meter 5s. per quarter.

The Electrical Resistance of the Human Body.—M. Von Frey has applied to the human body Kohlrausch's method of determining the resistance of electrolytes by means of alternating currents and the telephone. Certain modifications were found to be necessary. It was necessary to dispense with the metre measuring wire, since its resistance is so small compared with that of the human body that, in order to hear any sound at all, it is necessary to use induction-currents so strong as to be painful to the subject of experiment. The measuring wire was replaced by a circular groove not completely closed, filled with solution of zinc sulphate, in which the part connecting it with the telephone could be moved round like the hand of a clock. It was further found that platinum electrodes of 10 to 20 square centimetre surface, which Kohlrausch found quite sufficient for measuring the resistance of liquids, are by no means adequate with the human body to produce a cessation of sound in the telephone in any position whatever. It was only when the surface of contact between the metal and the moist hand was increased to several hundred square centimetres that the sound ceased, or, at any rate, there was a very

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pronounced meniscus. The surface necessary varies with the region of the body. In order uniformly to moisten large surfaces of the body, they were immersed in troughs through which the current was passed by cleanly polished zinc plates. In such conditions the resistance of the body was found to be very small (from hand to hand 3--400 ohms), and, as was to be expected, independent of the induction-currents.

A Novel Application of Storage Batteries to Electric Traction.—A most interesting exhibition of the application of storage batteries for propelling electric cars was given in Dover, N.H., July 12th, says the *Electrical Engineer* of New York. The road is operated by the Union Electric Street Railway Company, power being furnished from the station of the Great Falls Electric Light Company, situated on the Salmon Falls River. The road is full of steep grades, and in one part, about half a mile out of Dover, there is a grade of over nine per cent., which taxes the trolley system to the uttermost at all times, and when the cars are heavily loaded proves too much for it. In the past it has been found necessary to employ horses to aid the electric car in surmounting the grade. The station from which the current is derived is several miles away, so that there is a heavy fall of potential when the car is drawing on the current when ascending the hill. It was at last decided to try Bradbury-Stone storage batteries as an auxiliary. Accordingly in a small outhouse in the vicinity, 238 cells were installed, giving a total voltage of from 530 to 540 volts. The trolley wire on the hill is now cut off from the remainder of the system, and wires leading from the storage battery are connected to it, so that as soon as the trolley comes in contact with this section, which is about 300ft. long, the current is all taken from the batteries. The experiment has worked most successfully. On July 12th a very severe test was made. The special car containing about fifty people was hitched on to one of the regular trip cars, also well loaded, the one car pulling the other, and both ascended the hill without a hitch, the battery registering about 510 to 520 volts, and the current consumed being from 100 to 180 amperes.

Press Rates for Commercial Telegrams.—A number of traders and manufacturers recently petitioned the French Chamber of Deputies in favour of granting to commercial and industrial telegraphic despatches the reduced tariff applicable to press telegrams. M. Leconte, deputy, charged to report on the matter, has approved of the conclusions of the petition. He contends that journalism may be classed as a kind of trade. Political, industrial, and commercial communications which now serve to maintain and cover the expenses of the press, have an incontestable final object: to use the advantages that the circulation of journals offers for realising pecuniary benefits. Is that not also the object of all traders? If this similarity be admitted, why should that be refused to the one which is accorded to the other? Why should preference be given to journalism to the detriment of other commercial or industrial branches? If it be objected that the lowering of the telegraph rates would lead to a fall in the receipts of the Post-office for the exchange of correspondence, the reporter says it is easy to reply that the receipts from telegrams go, like those of the Post-office, into the coffers of the State. And it may be added that the rates for telegraphic correspondence, being incontestably higher than the rates for letters, it is to be presumed that the receipts from telegrams would be much augmented, and that consequently the State treasury, instead of being lightened, would be better filled. The reporter believes that the reform would result in a real benefit to the public treasury, whilst the adoption of the principle of the petition could not but favour the development of commercial and industrial transactions. The petition has been remitted, with a favourable opinion, to the Minister of Commerce.

The Proposed International Electrical Exhibition at Milan.—Preliminary steps for the organisation of an International Electrical Exhibition to be held at Milan in the spring of 1894, have been taken by a group of gentlemen connected with the professional and industrial interests involved. As it is necessary to decide upon the size of the buildings required for the Exhibition, the Committee have addressed forms for preliminary application for space to persons interested. No formal engagement need be entered into. All that is wanted is an assurance of intention to exhibit, and an approximate estimate of the space required. The Exhibition is an entirely private enterprise, and it has therefore been decided that the space occupied should be paid for by the exhibitors, at a moderate rate. It is considered that this contribution towards expenses may be fairly asked for, in view of the advantages, both direct and indirect, which exhibitors will secure themselves by promoting the success of the Exhibition. It is proposed to inaugurate a series of tests, and besides the usual medals a sum of money will, it is said, be put at the disposal of the jury, in order that a large premium may be allotted to the exhibit embodying the most important improvement brought forward at the Exhibition connected with the transmission of electrical energy to a distance and its subdivision and distribution for industrial purposes. The preliminary forms should be returned before August 15th, to the Exhibition Committee, 9, Via Unione, Milano. The Committee consists of Angelo Bertini, electrical engineer; Francesco Grassi, Professor of Physics at the Societá d'Incoraggiamento d'Arti e Mestieri; Palamede Guzzi, engineer; Cesare Saldini, Professor at the Istituto Tecnico Superiore; Augusto Stucchi, manufacturer.

Aluminium v. Copper.—In a recent number of the *Electrical World* Mr. A. Saunders Morris discusses the *pros* and *cons* of the employment of aluminium in electrical construction. Aluminium, he points out, is about one-third the weight of copper. The specific resistance is, however, almost twice as great as copper. The weight for an equivalent resistance will therefore be ·555 that of copper, or cost of aluminium $= \frac{\text{cost of copper}}{\cdot 555}$. The area of an aluminium wire of the same resistance as a copper wire having to be greater, the insulation for an aluminium wire would weigh about 36 per cent. more. The average saving in weight by using aluminium in place of copper for insulated wire, as estimated from manufacturers' tables, is 33 per cent. for the lowest grade of insulation, 22 per cent. for the next grade, and 18 per cent. for the best. If aluminium is used instead of copper in lead-covered cables, the weight, instead of being decreased, is increased. The disadvantages in the use of aluminium for electric conductors are: First, increased cross-section and its attendant circumstances, increased surface to be covered with insulation, increased surface exposed to wind, and increased danger from accumulations of snow and sleet, as well as the objectionable appearance of larger wires than at present used. Second, the great difficulty of soldering, although this objection is largely decreased by the use of mechanical joints not requiring solder. Third, the decreased tensile strength, which, however, is partly neutralised by the fact that the cross-section is nearly doubled. Its sole advantage is the decrease in weight; but the strength of poles is ample to support the weight of copper wire were it not for the side strains to which they are subjected, and which, in general, would be greater for aluminium than for copper. Mr. Morris next deals with the use of aluminium in the construction of transformers, dynamos, motors, &c.; and after balancing the decrease in the weight of the conductor circuit against the increase in weight of the magnetic circuit, &c., works out that the actual saving in weight is about 2 per cent.; but the volume being increased, the weight of the containing case would have to be increased, which would make the aluminium-wound transformer somewhat heavier than one wound with copper. If, again, aluminium were used instead of copper in a direct-current generator, the armature, to have the same ohmic resistance and the same air gap, would have to be considerably larger. This would in turn require larger fields, and these would have to be somewhat increased in general dimensions to accommodate the increased section of wire, so that in all probability what would be saved in weight by using aluminium would be lost on account of the greater weight of iron necessary for structural reasons; indeed, it would be difficult to use aluminium without changing the design materially, and probably sacrificing efficiency. The inability to use solder becomes a far more serious difficulty in machine construction than in line work. From the facts it would seem that, however great the usefulness of aluminium in general, its substitution for copper in the field of electricity is limited, even if its present price were materially reduced.

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LORD RAYLEIGH.

We publish this week a steel-plate portrait of Lord Rayleigh, Sec. R.S. Lord Rayleigh is the son of the second Baron Rayleigh, of Terling Place, Witham, Essex. He was born in 1842. He received his school education under Mr. Warner at Torquay, and in 1861 entered as a Fellow Commoner at Trinity College, Cambridge. From that time on, his mathematical powers began to show themselves, and in 1865 he graduated in the Mathematical Tripos as Senior Wrangler. He was also awarded the first Smith's Prize. In 1866 he obtained a Fellowship at Trinity, which he held till his marriage in 1871. He became a Fellow of the Royal Society in 1873. At present he is one of the Secretaries of the Society, and Professor of Natural Philosophy in the Royal Institution.

Lord Rayleigh's work in Physics has been of a very varied character; he has covered a wide range, and he has handled each subject with a thoroughness and clearness which have enabled him to add greatly to our knowledge in nearly every branch of the science. In attempting to give a very brief sketch of his work we may conveniently divide his life into three portions: the first lasting till 1879, when he succeeded Maxwell as Professor of Experimental Physics in Cambridge; the second, comprising the five years during which he held the Professorship; and the third, continuing from 1884 to the present time.

In the first period Lord Rayleigh's researches were mainly mathematical. The *Philosophical Magazine* for 1871 and 1872 contains a series of most important optical Papers, "On the Light from the Sky, its Polarisation and Colour," "On the Scattering of Light by Small Particles," "On the Reflection of Light from Transparent Matter," "On Double Refraction," and "On the Reflection and Refraction of Light by Intensely Opaque Matter." The results of these may be briefly summed up as follows:—The blue colour of the sky is caused by the scattering of light of the shorter wave lengths by the finer particles suspended in the air. Lord Rayleigh showed that the colour of this light and its polarisation could be satisfactorily accounted for on the undulatory theory; and, further, that to explain the observations, Fresnel's hypothesis as to the nature of the vibrations and their relation to the plane of polarisation, and not that of Neumann and MacCullagh, must be assumed. In the two Papers on Reflection and Refraction he calls attention to Green's work, bringing out clearly the points in which it fails to account for the facts, as well as its transcendent merits when compared with any other theory which had been proposed. The unsatisfactory character of Cauchy's theory of metallic reflection as shown by the results of Jamin's experiments is also discussed. In fact, these Papers, together with Sir G. G. Stokes's "Report on Double Refraction" in the B.A. Report for 1862, and his Paper on Diffraction, sum up the whole of what was then known of the dynamics of Optics. Other optical questions of a practical character are discussed in a communication to *Nature*, "On Some Experiments on Colour in 1871," which was followed by further work ten years later; and in Papers "On the Manufacture and Theory of Diffraction Gratings" (*Phil. Mag.*, 1871). Another series of Papers in the *Phil. Mag.* for 1873 deals with various theorems relating to vibrating systems in general; and the same subject was discussed in Papers read before the London Mathematical Society. This and kindred work culminated in the "Treatise on the Theory of Sound," the first volume of which was published in 1877, while the second followed in the next year. In connection with this the words of Prof. von Helmholtz, when reviewing in *Nature* the first volume, may be quoted:—"The author will merit in the highest degree the thanks of all who study Physics and Mathematics, if he continue it in the same manner in which he has begun it in the first volume."

A Paper on "Resonance" published in the *Philosophical Transactions* for 1871 needs special notice here, for in it Lord Rayleigh first developed a method of calculating approximately the resistance of conductors of any given form which has many and wide applications. Among experimental Papers of this period we may refer to two "On Some Electromagnetic Phenomena in Connection with the Dynamical Theory," and "On Electromagnetic Experiments" (*Phil. Mag.*, Vols. XXXVIII. and XXXIX.), in which some of the consequences of self-induction are discussed, and the effects of rapidly alternating currents in producing magnetism considered. In a Paper "On Waves" (*Phil. Mag.*, 1876) the theory of Scott Russell's Solitary Wave is developed. The Paper concludes with some interesting results on oscillations in cylindrical vessels. The *Proceedings* of the London Mathematical Society about this date contain many other Papers by Lord Rayleigh.

Clark Maxwell died in 1879, and shortly afterwards Lord Rayleigh was invited by an influential body of Cambridge men to be a candidate for the vacant chair. He consented, and was at once unanimously appointed. Maxwell's work had been to build the Cavendish Laboratory and to equip it with apparatus. The whole was the most generous gift of the Chancellor of the University, the late Duke of Devonshire. This work of preparation was barely concluded in 1879. It fell to Lord Rayleigh to organise the Laboratory in its twofold aspect. There was need for a school of experimental physicists, who might bring to bear on physical problems the skilled powers acquired by the training for the Mathematical Tripos; there was need also for teaching of a more elementary character to large classes of students who could gain by actual contact with apparatus, and by making measurements with their own hands, a far deeper insight into fundamental natural laws, the clear comprehension of which is in itself of the highest educational value, and which in many instances are of great practical importance to the student. Lord Rayleigh set himself to satisfy both these needs. Under his active supervision a system of practical instruction in Experimental Physics was devised. The number of students attending the classes grew rapidly from year to year. At first there were some five or six; in 1884, when Lord Rayleigh ceased to be Professor, there were seventy, while during the present academical year that number has grown to about one hundred and forty.

But Lord Rayleigh's own research work while Professor of Physics at Cambridge is of more interest to the readers of *The Electrician*. The experimental part of this is to be found mainly in the well-known quarto volume entitled "Electrical Measurements: Rayleigh," though we must not forget some optical and other Papers which will be mentioned shortly. The writings of Thomson (Lord Kelvin) and the experiments of Maxwell, Fleeming Jenkin, Matthiessen and Hockin had established the C.-G.-S. system of absolute electrical measurement. The experience of even a few years had shown the importance of a uniform system of measurements, and the need for accurate standards—an importance and a need which each succeeding year has only intensified. That we in England possess such standards of resistance, current and electromotive force as the result of English research, is due to Lord Rayleigh.

The B.A. unit was intended to have a resistance of 10^9 C.-G.-S. units; but the work of Joule, of Rowland, and of Kohlrausch had thrown doubt on this result. Cambridge was of all places the spot where it could best be repeated; for the apparatus originally used by Maxwell and his partners in King's College, where their measurements were affected by the iron of the passing steamers on the Thames, and the resistance coils which Matthiessen and Hockin had constructed to represent the results of the experiments, were in the Cavendish Laboratory. Dr. Fleming's recent intercomparison of these resistances had shown that it was highly improbable that they had changed, and so the first step was to set up the old Spinning Coil apparatus and repeat the experiments. This was done with the aid of Dr. Schuster. In the course of the reduction, one error made by the Committee was discovered. The value of the self-induction, which in this method comes in as an important correction, had been seriously under estimated, but this alone will not explain the discrepancy which the experiments proved to exist between the B.A. unit and the ohm; the result of the work gave as the value of the B.A. unit 0·9893 ohm. But the experiments had shown that the old apparatus was capable of great improvement in many of its details, and so a new coil was constructed and the whole repeated. Lord Rayleigh has a marvellous knack of seeing

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just the weak points of a method; and while, like Fresnel, who accomplished much of his work on diffraction with apparatus made by a country blacksmith, he can achieve results of the highest importance with materials of the simplest character, yet where refinement and accurate workmanship are really necessary for his purpose, these are employed with no grudging hand. Hence in this case the accuracy attained was considerably greater than before. The value actually found was $0{\cdot}9865 \times 10^9$.

The various methods of determining the standard of resistance were discussed by Lord Rayleigh in a Paper in the *Phil. Mag.* for November, 1882. As a result of his discussion he concludes that Lorentz's method is the best of all. Accordingly, he undertook, in conjunction with his sister-in-law, Mrs. H. Sidgwick, a determination by that method; the result of this, published in 1883, was 0·9868 ohm. Another series of experiments made at the Cavendish Laboratory in 1882 by Mr. Glazebrook, using Kirchhoff's method, gives the value 0·9867 ohm, while the mean of the seven most reliable experiments up to the present date is 0·98653. Various considerations had led electricians to the conclusion that the results of these experiments could be best expressed by determining the length of the column of mercury of a given cross-section 1 sq. mm., which has a resistance of 1 ohm; among other things, the evidence for the permanence of coils of platinum silver was not so strong as it is now. Thus it was necessary to find the specific resistance of mercury. This had been determined by Matthiessen and by Dr. W. Siemens, but their values differed by 0·8 per cent. Lord Rayleigh and Mrs. Sidgwick undertook this task, and their experiments are published in the *Phil. Trans.* for 1883. The value found for the resistance in B.A. units of a column of mercury, 100 cm. long, 1 sq. mm. in section was 0·9541, which is rather greater than the mean, 0·95354, of all the most reliable experiments.

But standards of current and of electromotive force are at least as urgently needed as standards of resistance; and the question of obtaining these was next dealt with in the Papers "On the Electro-Chemical Equivalent of Silver," and "On the Absolute Electromotive Force of Clark Cells" (*Phil. Trans.*, Part II., 1884). The problem differs from that of the standard of resistance in an important particular. A tube of mercury or a piece of wire has under given physical conditions a definite resistance. It is not possible to produce a concrete unit current, though we can arrange apparatus in which a certain effect is produced when the unit current is passing. The primary question to settle was, what effect of a current is to be taken. The fundamental property of a current on which the definition of unit current turns is its power of exerting magnetic force. The property investigated by Lord Rayleigh as a means of measuring a current was the electro-chemical deposition of silver; the object, then, of the research was to connect the two, to determine how much silver is deposited per second from a solution of nitrate of silver by a current which under certain circumstances exerts unit magnetic force on a magnet pole. Lord Rayleigh found that a current of one ampere deposits 0·0011179 gramme of silver per second; the result obtained by Kohlrausch is 0·0011183. The Paper contains details for carrying out the measurements necessary—these have been explained recently in *The Electrician* by Mr. Searle. It also deals with the electromotive force of various forms of cells, and shows that when proper precautions are taken in setting up the cell and preparing the materials, the electromotive force of Clark's cell is very constant, and is equal to 1·4345 volts at 15°C. Thus by these series of investigations Lord Rayleigh determined while at Cambridge the three fundamental units of resistance, current, and electromotive force.

Another piece of experimental electrical work was the measurement of Verdet's constant for bisulphide of carbon, the angle, that is, through which the plane of polarisation of light is rotated when travelling along lines of magnetic force between two points which differ in potential by unity. Suggestions, have from time to time been made for using this rotation as a means of measuring electric currents. Lord Rayleigh's investigations went to show that there is not much hope of success in this direction.

But these years, so fruitful in experimental work, were by no means barren in other respects. A series of Papers, "Investigations in Optics," published in the *Phil. Mag.* for 1879 and 1880, have thrown much light on the behaviour of various optical instruments; and a Paper "On the Electro-Magnetic Theory of Light" (*Phil. Mag.*, June, 1881) contains an application of that theory to the scattering of light by small particles.

In 1882 Lord Rayleigh was President of Section A of the British Association. In his address he discussed to some extent the relation of Mathematics to Experimental Physics, and expressed the wish, which many will re-echo, that he might "see a course of Mathematical instruction arranged with special reference to Physics, within which those whose bent was plainly towards experiment might, more or less completely, confine themselves." Two years later, in 1884, he occupied the Presidential chair at the Montreal meeting, and spoke in hopeful language of the future of applied electricity. He concluded with a tribute to Maxwell, into whose labours he had entered in a special sense, and "to whose influence, in conjunction with that of Thomson and of Helmholtz, is largely due that elimination of unnecessary hypothesis which is one of the distinguishing characteristics of the science of the present day."

Soon after his return from America Lord Rayleigh resigned his Cambridge chair. In 1885 he suceeeded Sir G. G. Stokes as one of the Secretaries of the Royal Society, and a few years later he became Professor of Natural Philosophy in the Royal Institution, in succession to Prof. Tyndall. Papers on a large variety of subjects have continued to flow from his pen; perhaps the most interesting to electricians are a series which appeared in the *Phil. Mag.*, Vols. XXI., XXII., and XXIII. The first of these deals with "The Self-Induction and Resistance of Straight Conductors." Prof Hughes, in his striking address to the Society of Telegraph Engineers, in January, 1886, had called attention to some of the effects due to induction in short pieces of wire. For the complete interpretation of his results, the value of the co-efficient of self-induction of a wire conveying a rapidly alternating current was required. The problem had, with some important limitations, been studied by Maxwell. Lord Rayleigh's work introduced some corrections into Maxwell's formulæ, and considerably extended his results. An experimental investigation of the problems treated by Prof. Hughes is given in the Papers on "The Self-Induction and Resistance of Compound Conductors" (*Phil. Mag.*, Vol. XXII., p. 469). An earlier Paper in the same volume, "Notes on Magnetism," p. 175, deals with some of the questions raised by Ewing's discovery of magnetic hysteresis; while in a third Paper (Vol. XXIII., p. 225), Lord Rayleigh showed that in the case of iron and steel for small magnetising forces, ranging for steel from $\frac{1}{3}$ to $\frac{1}{10000}$, of the earth's horizontal force, the magnetisation is strictly in proportion to the magnetising force; the value of μ for soft iron being about 90.

During the last year and a-half Lord Rayleigh has been a member of the Electrical Standards Committee of the Board of Trade, the outcome of whose work will be, should their report remain unmodified, to legalise, at any rate for the English-speaking countries of the world, his determinations of electrical standards. Space compels us to pass over in the briefest manner many of Lord Rayleigh's other contributions to science. In the article, "Wave Theory," in the "Encyclopædia Britannica," he has summed up in a masterly manner our knowledge of the theory of light; while, in various Papers scattered through the *Phil. Mag.* and elsewhere, he has dealt with individual optical questions of great interest. Chemists owe him a debt for his recent work on the relative densities of oxygen and hydrogen, for which he arrived at the number 15·882 (*Proc. Roy. Soc.*, Vol. L., p. 448), while the results he has attained in his Papers "On the Theory of Surface Tension," and "On the Tension of Water Surfaces, Clean and Contaminated" (*Phil. Mag.*, Vol. XXX., *Proc. Roy. Soc.*, Vol. XLVII.) have a wide bearing in many directions. A special interest attaches to the Paper "On Reflection from Liquid Surfaces in the Neighbourhood of the Polarising Angle" (*Phil. Mag.*, Jan. 1892), for in it Lord Rayleigh showed that light can be

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completely polarised by reflection from a clean surface; and this is what, according to the electromagnetic theory, should take place. We have thus reason for supposing that in all cases the Jamin effect, as it is called, *i.e.*, the want of complete polarisation, is due to surface-films; and the theory of reflection and refraction is much simplified.

This most inadequate account of Lord Rayleigh's life will, perhaps, suffice to show what he has done to carry on the work begun by Maxwell at the Cavendish Laboratory, and to secure for English Physics that high place in the world's esteem, which, thanks to the genius of Stokes and Kelvin, Maxwell and Rayleigh, it now holds.

ELECTROMAGNETIC THEORY.—XXXIV.

BY OLIVER HEAVISIDE.

(*Continued from page 328.*)

§157. If it be asked why, in the previous analogies, a preference has usually been shown for the representation of magnetic force (or a constant multiple thereof) by velocity, the answer would be, substantially, that it has been done in order to make the magnetic energy be kinetic. Now, it is true that in a perfectly abstract electromagnetic scheme, arranged in duplex form—in which every electric magnitude has its magnetic representative—and, therefore, including a magnetic conduction-current with waste of energy, there would be a perfect balance of evidence as regards the kinetic nature of either the electric or the magnetic energy, when the other is to be potential energy, as of a state of strain in an elastic medium. For, if it were argued from a certain set of relations that the magnetic energy was kinetic, the force of the argument could be at once destroyed by picking out an analogous set of relations tending to show (in the same way as before) that the electric energy was kinetic.

But, as matters actually stand, with an imperfect correspondence between the electric and magnetic sides of the electromagnetic scheme, there seems to be a considerable preponderance of evidence in favour of the kinetic nature of the magnetic energy. We may refer, in particular, to the laws of linear electric circuits, which were shown by Maxwell to be simply deducible by the ordinary equations of motion (generalised) of a dynamical system, on the assumption that magnetic energy is kinetic; there being one degree of freedom for every circuit, and the variables being such that every linear electric current is a (generalised) velocity. In this theory, the dielectric in which the conducting circuits are immersed is regarded as unyielding, so that electric displacement cannot occur in it, and the currents are confined entirely to the conductors.

Now, we could construct a precisely similar theory of conductive magnetic circuits immersed in a medium permitting displacement, but destitute of magnetic inductivity. The circuital flux of magnetic induction in the former case would now be replaced by a similar circuital flux of electric displacement; the former electric currents becoming magnetic currents, and the magnetic energy becoming electric energy. But this electric energy, when expressed in terms of the linear magnetic currents, would possess the property of allowing us to deduce from it the laws of the magnetic circuits, by using the generalised equations of motion, on the assumption that electric energy is kinetic, in a manner resembling Maxwell's deduction of the laws of electric circuits. Therefore, supposing the state of things mentioned to really exist, we might become impressed with the idea that electric energy is kinetic; just as, at present, it seems hardly possible to avoid entertaining the idea of the kinetic nature of the magnetic energy.

We do not, however, need to go to generalised dynamics to arrive at this probable conclusion. It is sufficient to start with a sound general knowledge of dynamical facts and principles, not necessarily mathematical, but such as may be acquired in practical experience by an intelligent and thoughtful mind, involving clear ideas about inertia, momentum, force, and work, and how they are practically connected (the Act of Parliament notwithstanding). On then proceeding to the experimental study of electrokinetics, including the phenomena of self-induction in particular, the dynamical ideas will be found to come in quite naturally. Lastly, the generalised theoretical dynamics will serve to clinch the matter. Although adding little that is novel, it will corroborate former conclusions, and co-ordinate the facts in a compact and systematic manner, suitable to a dynamical science.

On the other hand, there is little that is suggestive of kinetic ideas in electrostatics, whilst there is much that is suggestive of the potential energy of a strained state. This fact, combined with the kinetic suggestiveness of the facts (and the equations embodying them) in which magnetic induction and electric currents are concerned, explains why the association of magnetic with kinetic, and electric with potential energy becomes natural. It is, therefore, somewhat a matter of surprise, as well as rather vexing, to find that in order to extend the last-considered rotational analogy to a conducting dielectric, we must, if we wish to do it simply, give up the comparison of magnetic force with velocity and electric force with torque, and adopt the converse system, making the electric energy be kinetic, and the magnetic energy the potential energy of the rotation.

We can, perhaps most easily see that this plan should be adopted by writing down the two circuital equations of electromagnetism, and then, immediately under them, the corresponding proposed circuital equations of the rotational ether. Thus, taking $\mathbf{H}$ to be velocity, as before, we have, to express the first circuital law in the dielectric and its mechanical companion,

$$\mathbf{g} + \text{curl}\,\mathbf{H} = cp\mathbf{E}, \quad . \quad . \quad . \quad . \quad . \quad (357)$$

$$\mathbf{g}_1 + \text{curl}\,\mathbf{q} = \frac{1}{\nu} p(\tfrac{1}{2}\mathbf{S}). \quad . \quad . \quad . \quad (358)$$

Here the terms in vertical are to be compared. Magnetic force $\mathbf{H}$ becoming velocity $\mathbf{q}$, the electric force $\mathbf{E}$ becomes $\frac{1}{2}\mathbf{S}$, or half the torque; c the permittivity is the compliancy ν^{-1}, and $\mathbf{g}_1$ is a newly-introduced companion to $\mathbf{g}$, which is the source $-\text{curl}\,\mathbf{h}$. It will be interpreted later.

The other circuital equations are

$$\mathbf{f} - \text{curl}\,\mathbf{E} = \mu p\mathbf{H}, \quad . \quad . \quad . \quad . \quad (359)$$

$$\mathbf{f}_1 - \text{curl}\,(\tfrac{1}{2}\mathbf{S}) = \rho p\mathbf{q}. \quad . \quad . \quad . \quad . \quad (360)$$

We now have the additional analogues of inductivity and density, and $\mathbf{f}$, which is the source curl $\mathbf{e}$, with $\mathbf{f}_1$, which is impressed translational force per unit volume.

So far relating to a non-conducting dielectric, and giving an intelligible dynamical analogy, if we wish to extend it to a conducting dielectric, according to Maxwell's scheme (including, of course, a pure conductor which has, or is assumed to have, no permittivity), we require to change cp in the first circuital law (357) to $k + cp$, whilst the second circuital law needs no change. But the right number of (358) needs to be changed to match the modified (357). Thus

$$\mathbf{g} + \text{curl}\,\mathbf{H} = (k + cp)\mathbf{E}, \quad . \quad . \quad . \quad . \quad (361)$$

$$\mathbf{g}_1 + \text{curl}\,\mathbf{q} = (k_1 + \nu^{-1}p)\,(\tfrac{1}{2}\mathbf{S}), \quad . \quad . \quad (362)$$

where k_1 is the new coefficient, to match k. But what is its interpretation in the rotational ether, and how is the latter to be modified to make k_1 as intelligible as the other constants?

Now, since we use rotational elasticity to obtain the potential energy, and we associate the rotation with the electric displacement, it is suggested that rotational friction should be introduced to cause the waste of energy analogous to that of Joule. But if there were frictional resistance proportional to the spin, we should have

$$\mathbf{S} = 2(\nu + \nu_1 p)\,\text{curl}\,\mathbf{G}, \quad . \quad . \quad . \quad . \quad (363)$$

instead of (352), connecting the torque with the rotation. But this will not harmonise at all with (362). We cannot do what we want by rotational friction, but require some special arrangement, whose nature does not appear, in order to interpret (362) intelligibly.

But, by changing the form of the analogy, choosing the electric energy to be kinetic, the extension to a conducting

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dielectric can be made in a sufficiently obvious manner. Put (360) under (361), thus

$$\mathbf{g} + \operatorname{curl} \mathbf{H} = (k + cp)\mathbf{E}, \quad . \quad . \quad . \quad . \quad (364)$$

$$\mathbf{f}_1 + \operatorname{curl} (-\tfrac{1}{2}\mathbf{S}) = (\rho_1 + \rho p)\mathbf{q}, \quad . \quad . \quad . \quad (365)$$

where we introduce ρ_1 to match k. Also put (358) under (359), to get the other pair, thus

$$\mathbf{f} - \operatorname{curl} \mathbf{E} = \mu p \mathbf{H}, \quad . \quad . \quad . \quad . \quad (366)$$

$$-\mathbf{g}_1 - \operatorname{curl} \mathbf{q} = \frac{1}{\nu} p(-\tfrac{1}{2}\mathbf{S}). \quad . \quad . \quad . \quad (367)$$

We have now a fit, with an intelligible meaning to be given to the new coefficient that brings in waste of energy. For (365), which is compared with the first circuital law, is the translational equation of motion in the rotational ether when there is frictional resistance to translation, expressed by $\rho_1\mathbf{q}$, so that ρ_1 is the frictionality, and $\rho_1\mathbf{q}^2$ the rate of waste.

The correspondences in detail are as follows:—

	$\mathbf{A} = \mathbf{E}/p$	stands	for	$\mathbf{G}$,	(spacial displ.).
(el. force)	$\mathbf{E}$	,,	,,	$\mathbf{q}$,	(velocity).
(permittivity)	c	,,	,,	ρ,	(density).
(el. displ.)	$\mathbf{D}$	,,	,,	$\rho\mathbf{q}$,	(momentum).
(el. energy)	$\frac{1}{2}c\mathbf{E}^2$	,,	,,	$\frac{1}{2}\rho\mathbf{q}^2$,	(kin. energy).
(mag. force)	$\mathbf{H}$	,,	,,	$-\frac{1}{2}\mathbf{S}$,	($-\frac{1}{2}$ torque).
(inductivity)	μ	,,	,,	ν^{-1},	(compliancy).
(induction)	$\mathbf{B}$	,,	,,	$-\frac{1}{2}\nu^{-1}\mathbf{S}$,	
(mag. energy)	$\frac{1}{2}\mu\mathbf{H}^2$	,,	,,	$\frac{1}{2}\nu(\operatorname{curl}\mathbf{G})^2$,	(rotl. energy).
(conductivity)	k	,,	,,	ρ_1,	(frictionality).
(cond. current)	$\mathbf{C} = k\mathbf{E}$	,,	,,	$\rho_1\mathbf{q}$,	
(Joule-heat)	$k\mathbf{E}^2$	,,	,,	$\rho_1\mathbf{q}^2$,	(rate of waste).
(true current)	$\mathbf{C} + p\mathbf{D}$	,,	,,	$(\rho_1 + \rho p)\mathbf{q}$.	

These should be studied in connection with the circuital equations (364), (366), and their matches underneath them, if it be desired to obtain "an intelligent comprehension" of the true nature of the analogy, and to correct any errors that may have crept in.

If we keep away from the sources of energy, there is little difficulty in understanding the analogy in a broad manner. But the sources require special attention before the electromagnetic and rotational analogues are intelligible. We know that activity is the product of two factors a "force" and a "velocity." Newton knew that. In modern dynamics, too, where the velocity is not a primitive velocity, but has a generalised meaning—the time-rate of change of some variable—the corresponding force generalised (not a primitive force) is still such that the product of "force" and "velocity" is activity, or activity per unit volume, &c., according to convenience. In our electromagnetic equations, for instance, $\mathbf{EC}$ and $\mathbf{H}\dot{\mathbf{B}}$ and $\mathbf{E}\dot{\mathbf{D}}$ are activities (per unit volume), and we call $\mathbf{E}$ and $\mathbf{H}$ the "forces" (intensities) and the other factors the fluxes, the corresponding "velocities." Similarly, $\mathbf{eC}$, $\mathbf{e}\dot{\mathbf{D}}$, and $\mathbf{h}\dot{\mathbf{B}}$ are activities (per unit volume understood), where $\mathbf{e}$ and $\mathbf{h}$ are intrinsic, communicating energy to the system.

Now, since the "variables" may be variously chosen in a dynamical system, we need not be surprised if it should sometimes happen that the (generalised) force turns out to be a (primitive) velocity, and the (generalised) velocity to be a (primitive) force. Here is food for the scoffer, for one thing. At any rate, we should be careful not to confound distinct ideas, and remember the meaning of the activity product. Our present rotational analogy furnishes an illustration. We have the equation of activity,

$$\mathbf{e}(\mathbf{C} + \dot{\mathbf{D}}) + \mathbf{h}\dot{\mathbf{B}} = \mathrm{Q} + \dot{\mathrm{U}} + \dot{\mathrm{T}} + \operatorname{div} \mathbf{W}, \quad . \quad (368)$$

where

$$\mathbf{W} = \mathrm{V}(\mathbf{E} - \mathbf{e})(\mathbf{H} - \mathbf{h}). \quad . \quad . \quad (369)$$

$\mathbf{W}$ is the energy-flux, Q the rate of waste, U the electric, and T the magnetic energy per unit volume, whilst the left member represents the rate of supply of energy by the intrinsic sources $\mathbf{e}$ and $\mathbf{h}$, being the sum of their activities.

Now what are the analogues of $\mathbf{e}$ and $\mathbf{h}$? Remember that only their curls appear in the circuital equations and that $\mathbf{f}$ and $\mathbf{g}$ are the sources of disturbances. By inspection of (365), (367), we see that $\mathbf{f}_1$ is the curl of a torque, and $\mathbf{g}_1$ the curl of a velocity, say

$$2\mathbf{f}_1 = \operatorname{curl} \mathbf{S}_0, \qquad \mathbf{g}_1 = -\operatorname{curl} \mathbf{q}_0. \quad . \quad . \quad (370)$$

Then, just as the analogue of $\mathbf{H}$ is $-\frac{1}{2}\mathbf{S}$, the analogue of $\mathbf{h}$ is $-\frac{1}{2}\mathbf{S}_0$. Impressed magnetic force is, therefore, represented by an impressed torque per unit volume, and its activity is

$$(-\tfrac{1}{2}\mathbf{S}_0)\nu^{-1}p(-\tfrac{1}{2}\mathbf{S}), \quad . \quad . \quad . \quad . \quad (371)$$

which is, of course, plain enough. But the other activity is

$$\mathbf{q}_0(\rho_1 + \rho p)\mathbf{q}, \quad . \quad . \quad . \quad . \quad . \quad (372)$$

where $\mathbf{q}_0$ is the analogue of $\mathbf{e}$. Here the supposed "force" has become a velocity, and the "velocity" a force. For the factor of $\mathbf{q}_0$ in (372) is the analogue of electric current-density, and means the (primitive) force per unit volume in the rotational ether, partly employed in increasing momentum, partly working against friction. Of course this perversion is rather extreme.

The rotational analogues of (368), (369) may be readily written down by proper translations in accordance with the above, remembering (370).

Mr. W. Williams, who has recently (Physical Society, 1892) published a very close study of the theory of the "dimensions" of physical magnitudes, on applying his views to the electromagnetic equations and the rotational ether, has arrived at the conclusion that the representation of either $\mathbf{E}$ or $\mathbf{H}$ by velocity leads to the only two systems that are dynamically intelligible. It should be remembered, however, that his conclusion is subject to certain limitations (mentioned in his paper) regarding dimensions, for otherwise the conclusion might seem to be of too absolute a nature, as if one of $\mathbf{E}$ or $\mathbf{H}$ *must* be velocity. In any case, I cannot go further myself at present than to regard the rotational ether as furnishing a good analogy, which may lead later to something better and more comprehensive. The present limitation to small motions (in general) is a serious one, and there are other difficulties.

(To be continued.)

ON THE RATE OF PROPAGATION OF ELECTRO-MAGNETIC OSCILLATIONS IN INSULATING MEDIUMS, AND ON MAXWELL'S RELATION.*

BY R. BLONDLOT.

Considerations of homogeneity lead to an extremely simple relation concerning the propagation of electro magnetic waves in different insulating mediums. If we take an electric oscillator made of an extremely good conducting metal, the waves which it is capable of emitting when it is at work in a certain medium have a length which can only depend on the shape and size of the oscillator on the one hand and of the electrical properties of the medium on the other. Assuming this medium to be an insulator, its electrical properties are defined by a single coefficient, viz., its dielectric constant or specific inductive capacity, K, the magnetic constants of all known dielectrics being sensibly equal to each other. It follows that λ can only be a function of a certain number of lengths defining the shape and size of the oscillator and the coefficient K. On the other hand, the numerical value of K depends on the unit of time chosen,† which may be an arbitrary one. It is impossible, therefore, that the expression λ, which is a length, should contain K; hence *for a given oscillator the length of the waves which it is capable of emitting should be the same whatever the insulating medium in which the experiment takes place.*

I have verified this hypothesis in the case of liquid dielectrics. The electric waves were produced and transmitted by the method which I have described,‡ along two parallel wires of tinned copper eight centimetres apart. A gilded copper resonator, similar to that which I employed to determine the rate of propagation of electric waves, was arranged between the two wires. The portion of the resonator forming the condenser was contained in a glass vessel. The portion of the transmission

* From *Comptes Rendus*, Vol. CXV., p. 225.

† The dimensions of K are $L^{-2}T^2$.

‡ *Comptes Rendus*, Vol. CXIV., p. 283; see also *The Electrician*, Vol. XXVIII., p. 627.

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wires situated on the far side of the resonator was contained in a wooden trough four metres long. The glass vessel and the trough being empty, I determined the position of the movable bridge for non-sparking. The distance of this bridge from the resonator was therefore one-fourth of the wave length proper to the resonator; there was no necessity to measure this, and I contented myself with marking exactly the position of the bridge. This done the vessel containing the condenser was filled with the liquid chosen. It was ascertained that the wave length became greater (it increased from 14·8 metres to more than 25 metres in an experiment made with essence of turpentine). The trough was then filled with the same liquid, and in determining once more the position of the bridge involving the disappearance of sparking in the resonator, it was ascertained that this position was exactly the same as in the first part of the experiment, when the glass vessel and the trough contained air. The experiment was equally successful with both the dielectrics which I employed, viz, essence of turpentine and castor oil.* The verification of the law was complete.

It may be remarked that acoustics present us with an analogous phenomenon, a sounding tube always emits waves the length of which depends solely upon that of the tube, and is consequently independent of the nature of the atmosphere in which the vibrations are caused to take place.

From the above law I deduce the important consequence which M. Potier has also noticed. Between the capacity C and the coefficient of self-induction L and the period T of my resonator the following relation exists:—

$$T = 2\pi\sqrt{CL},$$

whence multiplying both sides of the equation by V, the rate of propagation of the waves, we have

$$\lambda = 2\pi\sqrt{L} \times \sqrt{C} \times V,$$

and as λ and L are independent of the nature of the dielectric medium the product C V ought also to be so. Hence in passing from air to another dielectric the value of C becomes K times greater, and the value of V should be multiplied by the reciprocal of the index of refraction $\left(\frac{1}{n}\right)$ of the new medium; Hence we ought to have $K \times \frac{1}{n^2} = 1$, or $K = n^2$.

This is the relation arrived at theoretically by Maxwell.

I have thus verified this relation for the two liquids which I employed, and my experiments confirm those of Messrs. L. Arons and H. Rubens, recently published.† Castor oil has a special interest since when we try to deduce from the values of the luminous indices of this substance the index which would correspond to infinite wave length by aid of the dispersion formula of Cauchy, we obtain the number 1·4674, whilst the square root of the dielectric constant is 2·18.‡ Maxwell's relation, therefore, seems in fault, but it is the method of verification which is incorrect. I would remark that my experiments rigorously fulfilled the conditions demanded in order that Maxwell's relation should be applicable, viz., that the values K and n should relate to phenomena of the same period; they offer, moreover, the advantageous circumstance of being independent of all measurements, since they are only based upon the determination of the equality of two lengths.

It must not be thought that the reasoning founded on considerations of homogeneity, which led me to Maxwell's relation, should necessarily be applicable to all dielectrics, and that experimental verifications are superfluous. This reasoning supposes, in fact, that the dielectric properties of the medium are defined by a single dielectric constant. If several coefficients were necessary, the wave length corresponding to a given oscillator could no longer be independent of the medium, and Maxwell's relation might fail. Experiment, therefore, can only ultimately decide the matter.

I am indebted greatly to M. M. Dufour, who has helped in the most kind manner in carrying out these experiments.

* I will explain further on why castor oil possesses particular interest.

† *Weid. Ann.*, Vol. XLII., p. 581; see also *The Electrician*, Vol. XXVII., p. 157.

‡ *Weid. Ann.*, Vol. XLII., p. 582.

COMMUTATORS.—IV.

BY F. M. WEYMOUTH.

(*Concluded from page 335.*)

It is essential with all commutators that they be driven direct from the shaft. Hence we find in Figs. 12 and 14 (see p. 334 of last issue) that the sleeve is keyed to the shaft, while in Figs. 3, 4, 8 and 13 a steel pin is driven into the shaft, as at g, for this purpose. The nuts, whether of gunmetal, wrought iron, or steel, are usually circular, with radial holes or else rectangular notches in the rim, for the use of a tommy to tighten up with. But, as shown in Fig. 12, horizontal holes parallel with the shaft may also be adopted; while two flats, one on each side the nut, for the use of a spanner, is another method.

But now, however, to turn aside from the consideration of the interior construction of different forms of commutators, we may give our attention to some remaining items, which are more or less independent of the interior construction. Thus, we may notice some of the various methods in which the lugs are dealt with, and connection formed with the armature winding.

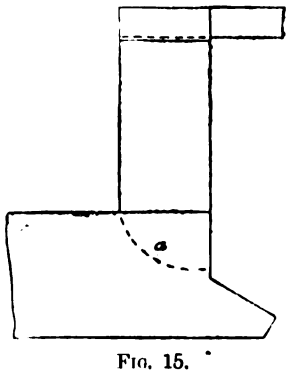

Fig. 15.

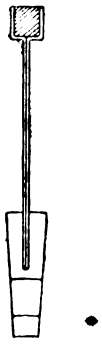

Fig. 16.

As already intimated, the commutator lugs may be either cast in one with the segments, or they may be separate pieces soldered or brazed in. This latter has of necessity to be the method adopted when the segments are of rolled copper, except, perhaps, when, as in cases previously alluded to, the armature is wire wound, and the commutator large in proportion. The lugs when separate are frequently made of two strips of copper rivetted together, opening out into a fork at the outer end to receive the winding end. This is shown herewith, Figs. 15 and 16. The nitch in the segment receiving the inner ends is cut out with a small circular saw, which accounts for the rounded corner a.

Fig. 17.

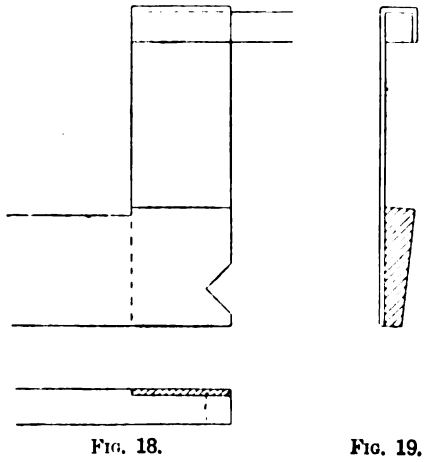

Fig. 18.

Fig. 19.

Figs. 17 to 19 are other variations. Here one strip only is used, bent over at the top as shown, so as nearly to enclose the winding end soldered into it; and the inner end, instead of being received in a nitch, lies in a recess at the side of the segment, which may, however, be cut with a saw the same as the nitch. A very common way, instead of enfolding the

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winding end when this is a bar, is to make a saw cut in the bar end to receive the outer end of the lug, as shown in Figs. 20 and 21. The lug is then simply a straight strip of copper, received and soldered or otherwise fastened into a saw cut at

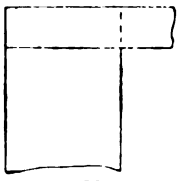

Fig. 20.

Fig. 21.

both ends. A case where rolled segments may be combined with wire winding without the use of additional lugs is illustrated in Figs. 22 and 23 herewith. *Quasi* lugs are formed by turning a groove *d* in the segments.

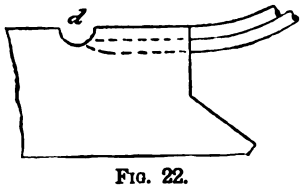

Fig. 22.

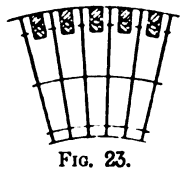

Fig. 23.

Turning our attention now to cast segments, we find a common form in Figs. 24 and 25. Here very short lugs only are necessary, with wire winding, when, as in the previous

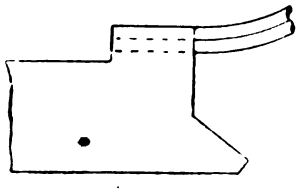

Fig. 24.

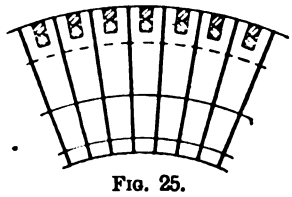

Fig. 25.

figures, the wire can easily be bent down to the smaller diameter of the commutator. In the case, however, of bar-wound armatures for heavy currents, where the bar ends cannot be

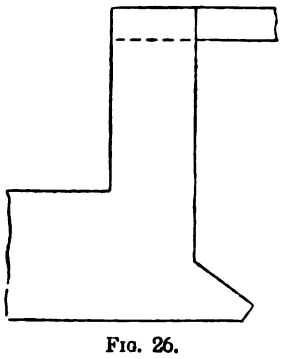

Fig. 26.

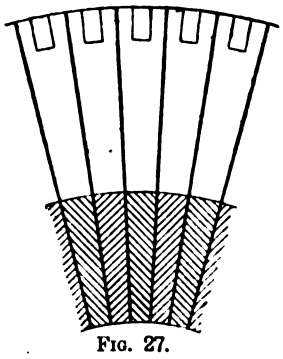

Fig. 27.

brought down, the lugs must then extend to the full diameter of the armature, as illustrated in Figs. 26 and 27. This looks

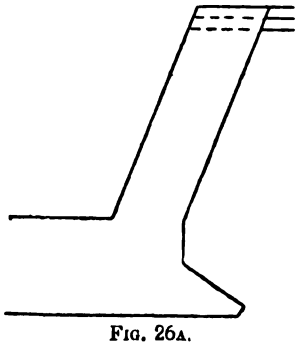

Fig. 26A.

very neat, the lugs being all turned up bright as well as the brush contact surface. Fig. 26A is a variety where the lugs are sloped toward the armature. This has the advantage of allowing more room for the brush-holder, so that the brushes can bear right up to the roots of the lugs. It also practically eliminates the short piece of single conductor bar that passes from the armature end winding to the lugs. For this piece has to carry the *whole* current when in series with the brush, and being only of a size adapted properly to carry but *half* the current, it offers a resistance. Generally, however, this is considered neglible owing to the shortness of the piece; and the bar does not heat as it otherwise might, owing to the fact that it revolves in the open air, and so is kept cool. But another variety

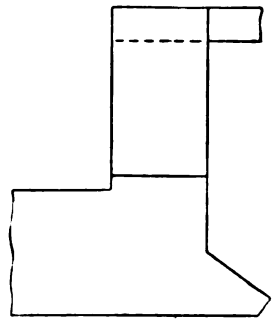

Fig. 28.

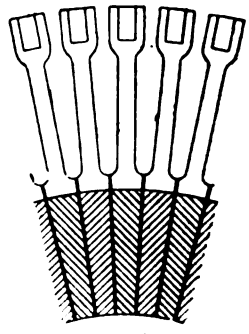

Fig. 29.

of the same thing is shown in Figs. 28 and 29. Here, it will be seen, the lugs, instead of being carried out solid to the outer periphery, are considerably lightened, and open spaces left between them. This latter arrangement, especially when there is much difference between the diameters of the armature and commutator, must be decidedly more economical. For there is less metal and less insulation than in the former, and labour is saved in not having to machine or file up the sides of the lugs. Ventilation, moreover, is completely stopped in Fig. 27, but not in Fig. 29. A good example, however, of the method shown in Figs. 26 and 27 occurs in the case of the two

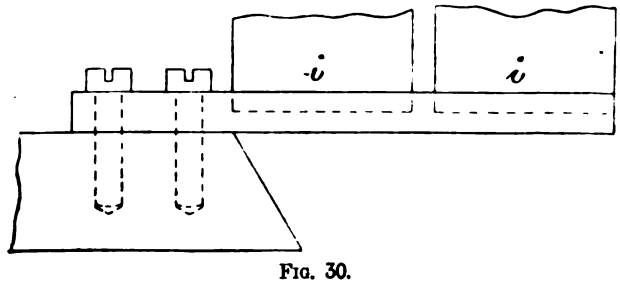

Fig. 30.

commutators of the Elwell-Parker motor generator, or continuous-current transformer, already once alluded to. For here the commutators, especially the high-tension, are abnormally large in diameter. Fig. 30 illustrates a further method of connection, used in the case of the Hopkinson adaptation of the Hefner-Alteneck end winding for drum armatures. Here union is made with the interior ends of the cross connections, instead of to the exterior. Hence a bar, screwed to the segments, and soldered or brazed or otherwise fastened to the ends of the involutes *i i*, is all that is required for the purpose.

EARTH CURRENTS.

The following notes based on reports sent in by cable stations extending from London to Singapore exhibit in a striking way the ubiquity and simultaneity which so frequently characterise earth-current disturbances. It was thought at first that there was evidence to connect this "magnetic storm" with the eruption of Etna, but in looking into the matter it was found that the eruption began about a week before July 16th, although indeed it was very active on that date. It is interesting to note that the Atlantic cables were similarly affected on the date named, and at about the same time.

London.—Earth currents were observed on all the circuits between London on the one hand, and Porthcurnow, Manchester and Liverpool,

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Glasgow and Paris on the other, between 12 p.m. and 8:30 p.m. on Saturday, the 16th ult. At about 12:40 p.m. every wire was stopped from this cause, the appearance and disappearance being simultaneous on each. Between 4 and 8:30 p.m. the currents were very pronounced, but occurred only at intervals, and not invariably at the same moment on all circuits.

Falmouth.—Some of the traffic was nearly stopped on Spanish lines on July 16th, including the Madrid-Barcelona, Madrid-Bordeaux wires, on account of earth currents, which were very irregular in tension, but mostly of positive sign. On July 17th the earth currents on the Bilbao cable were about four times the normal tension. The London-Falmouth land line was much affected on the 16th ult. and 17th ult., but not on the 18th ult.

Porthcurnow.—No abnormal earth currents were observed on the cables to Spain and Portugal during the week preceding the 18th ; but some interference from this cause on land lines was noticed between 4 and 6 p.m. on the 12th ult., also at intervals between noon and 8 p.m. on the 16th ult., and from midnight to 2 a.m. on the 17th ult.

Gibraltar.—Here there were strong earth current disturbances on the Cadiz and Tangier cables between noon on July 16th and 2:30 a.m. on July 17th.

Marseilles.—On Saturday, the 16th, 7:40 p.m., to Sunday, the 17th, 2:40 a.m., the London and Paris wires were affected by strong earth currents, the Algiers cables being affected at the same time, but less intensely. The Eastern Company's lines to Bona and Malta were not influenced.

Bona.—At Bona earth currents were observed on Friday, July 15th, at 10 p.m. There was a large deflection on the mirror when working through between Marseilles and Malta, stopping positive current coming from Malta, and shifting the spot at Bona. No deflection was observed when working in section ; but at Bona a large condenser of 20 microfarads is used.

Malta.—A strong and variable earth current was experienced on the Zante section on July 16th, between 1 and 1:30 p.m.; also during greater part of the same evening, and again between 9 and 9:30 a.m. on the 17th. Nothing was noticed on the other sections.

Zante.—On Saturday, July 16th, all the sections worked with great difficulty, owing to the excessively strong earth currents, especially on Trieste, Athens, and Syra circuits. All the Italian land lines were affected.

Alexandria.—On Saturday, July 16th, at 5:25 p.m. (Greenwich time), strong earth currents on land-lines and on cables were noticed ; the syphon vibrated to the extent of about a quarter of an inch for a few seconds only, nothing was noticed before or after.

Suez.—On July 16th, at 7:30 p.m. (Cairo time), strong earth currents were present on all the cables to Suakim, Perim and Aden for a short time.

Bombay.—Strong earth currents occurred on the Aden cable at 10:40 p.m. on July 16th, but they did not stop work. The Government lines were affected on the 16th at 2:30 until 8 a.m. on the 17th, and again on that date from 4:30 p.m. to 6 p.m.

Singapore.—There was a slight earthquake at Banjoewangie 1:50 a.m. on July 14th, and the signals on the Sinagapore Banjoewangie cable became feeble at 3 a.m. On Saturday night, July 16th, and on Sunday, July 17th, there were very strong earth currents on all sections to Batavia, Penang and Saigon, which died away on July 18th. A considerable fall of insulation on the Saigon-Hongkong and Shanghai cables was reported.

LEAD ACCUMULATORS FROM A CHEMICAL STANDPOINT.*

BY G. DARRIEUS.

In the introduction the author points out, that although the most generally accepted hypothesis concerning the reactions occurring during discharge in lead batteries is that sulphating takes place at both plates, it is scarcely probable that the same body, SO_3 for example, acts at both electrodes at the same instant. The formation of the same body by electrolysis at each electrode is contrary to Faraday's law, and the theory of double sulphating at both plates appears to have been adopted because it brings Lord Kelvin's law into harmony with the results of experiment.

Physical and Chemical Constitution of the Accumulators before Discharge.

At the commencement of charge the positive plate may be supposed to consist simply of metallic lead, and what happens during charge is in agreement with the laws of electrolysis. The lead is oxidised and acquires a characteristic tint, and if the charge is stopped at the moment when the colour is uniform and gas is given off freely, and the plate is then dipped into a vessel of pure water, a syrupy liquid flows from the bottom of the plate, whilst small bubbles of gas break on its surface. The gas is oxygen, and suggests the presence of some unstable peroxide body which is decomposed by the water. The peroxide body was found to be persulphuric acid, and it was further found that it was always present at the positive plate from the very commencement of charge when the density of the acid was 1·034 and over. No very exact determination of the oxygen wasted in oxidising the acid could be made, but it was very appreciable in amount, and traces of persulphuric acid were found in the drippings from plates which had been standing idle some days. The surface of the plates was found to consist at the end of charge of peroxide of lead impregnated with persulphuric acid for the positives, and metallic lead containing traces of hydrogen at the negatives. The acid from the negatives contained traces of persulphuric acid.

Physical and Chemical Constitution after Discharge.

Analyses of the positive plates after discharge showed that they consisted of a mixture of peroxide of lead, oxide of lead, and lead sulphate, and that while there was always a relation between the total quantity of peroxide reduced and the ampere hours, there was none between the sulphate of lead formed and the latter.

As to the electrolyte, its density became lower during discharge and persulphuric acid decreased.

The negative plates were found to consist after discharge of lead and lead sulphate, and the lead sulphate formed showed a close agreement with the amount required by theory.

Discussion of the Results.

The high initial E.M.F. is ascribed by the author to the joint action of the small quantity of occluded hydrogen in the lead plates, and the persulphuric acid at the positive plates, while the energy furnished during the steady part of the discharge is attributed to the reduction of the peroxide of lead to some lower oxide and the oxidation of the lead plate. In both cases sulphating follows from local action. In support of his view that the primary action of discharge is the formation of some oxide, the author describes the result of discharging a cell containing a solution of sodium sulphate as electrolyte. The E.M.F. was slightly lower than with sulphuric acid, and no lead sulphate was formed, but the surface of the plate after discharge consisted of a mixture of metallic lead and the sub-oxide of lead.

On charging the cell persulphuric acid is formed at the positive plate, and peroxide of lead is formed by degrees as the charge proceeds, some lower oxide being the first product, as shown in the following equations :—

$$(1)\ Pb + 2SO_3 + O = PbO + 2SO_3.$$

$$(2)\ PbO + 2SO_3 + O = PbO_2 + 2SO_3.$$

The action of persulphuric acid during charge is to bring the whole of the active material to the peroxide state, and the author points out that unless the conditions are such that the existence of this body is possible, peroxide of lead is not formed by electrolysis.

Application of Lord Kelvin's Law.

At the commencement of discharge the law is in practical harmony with observed values, whether water or sulphuric acid is regarded as the electrolyte, if the presence of persulphuric acid is allowed for, the E.M.F. in the two cases being 2·07 volts and 2·15 volts respectively ; but during the steady portion of the discharge which is due to the reduction of PbO_2 to PbO the application of the law only gives an E.M.F. of 1·32 volts, while the observed E.M.F. for lead and PbO_2 in sulphuric acid is 1·6 volts, that is for a PbO_2 plate which has been washed and dried to free it from peroxides. On replacing the clean lead plate by one of spongy lead, without touching the positive, the E.M.F. rises to 1·93 volts. The author concludes therefore that the apparent want of agreement between Lord Kelvin's law and the results of experiment is due to the physical state of the lead plates, and points out that both Schützenberger and Gore have shown that certain metals, amongst which is lead, are not obtained in their normal state by electrolysis, and that they give out heat on passing into it.

* Abstract of a Paper read before the Société Internationale des Electriciens, *Bulletin* IX., 88, pp. 205–228.

BOOKS, &c., RECEIVED.

"Practical Sewage Purification." (Manchester : Cuthbertson and Black.)

"An Appeal to the Canadian Institute on the Rectification of Parliament.) By Dr. Sandford Fleming. (Toronto : The Copp Clarke Company.)

"Fortschritte der Elektrotechnik." By Dr. Karl Strecker. (Berlin : Julius Springer.)

"Induction Coils." By G. E. Bonney. (London and New York : Whittaker and Co.)

"Scientific and Technical Papers of Werner von Siemens." Vol. I. Translated from the Second German Edition. (London : John Murray.) Price 14s.

"Lessons in Heat and Light." By D. E. Jones, D.Sc. (London : Macmillan and Co.) Price 3s. 6d.

"Die Elektrischen Accumulatoren." By J. Sack. (Leipzig : A. Hartleben.)

"Elektricitätswerk Frankfurt-a-M." Gutachten und Projecte von Oskar von Miller und W. H. Lindley.

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INDUSTRIAL ELECTROLYSIS.

A tyro in technology confronted with the problem of preparing any one of the less complex products of modern industrial chemistry, and acquainted with the elementary truths of electrolysis, would certainly not hesitate to recommend the adoption of a method which went straight to the object aimed at, formed few or no bye-products, and consumed energy only in quantity directly proportional to the useful work effected. It may well be that these surface recommendations are largely the cause of the prevalence of the tyro in the domain of the electro-chemist. Far be it from us to sneer at effort more or less amateur; those who are in a position to transform the crudities of guerilla attempts into fully-elaborated evolutions of the industrial army have to a certain extent neglected their trust and ignored the possibilities of the new weapon presented to them; and any endeavour on their part to decry the enterprising, if somewhat irresponsible, tactics of their irregular comrades would come with singularly bad grace. There is no denying, however, that the best of amateur technologists make rather a ragged squad, even when individually efficient; what then must be the condition of a regiment of which the members themselves are indifferently equipped? Dropping our military simile, let us ask what prospect of success is possessed by the *soi-disant* electro-chemist who is not only unfamiliar

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with the exigencies of modern chemical manufacturing processes, but is imperfectly acquainted with the principles on which they depend? But one answer is possible.

The mingled ignorance and indifference that have delayed the development of industrial electrolysis by something like a score of years, owe their persistence mainly to the fact that, for their dissipation, men of special training and powers were required, who should be at once sound chemists and competent electricians; and, as in all similar cases where a subject lies on the border line of two others, older and already received as the basis of reputable professions, persons uniting these qualifications were rare, and chary of rubbing shoulders with the somewhat shady adventurers who make borderlands of all kinds their hunting-ground. It is, therefore, with peculiar satisfaction that we find one at least who has abandoned this attitude of aloofness, and done something to map out territory already discovered, and to indicate its capabilities. Mr. JAMES SWINBURNE has collected into a lengthy but lucid Paper the chief facts essential to an understanding of the present position of electrolytic processes of all kinds, and has thus brought into a compendious and accessible form information that was scattered or buried. The Paper which is presented to the Institution of Electrical Engineers is already circulated in proof form; but its discussion will not be taken until after the beginning of the next session, thus inaugurating a healthy reform which we have long advocated. Papers of solid and serious import cannot adequately be considered in the space of one evening, or even two, following immediately on their lection, and there appears no good reason why time should not be accorded for the weighing of arguments and the consultation of references necessary for their intelligent appreciation. If the practice of issuing advance proofs were more general, there would, it is to be hoped, be less of the irrelevant and platitudinary oratory that often converts what should be both pleasant and profitable into a dreary waste of time, temper, and energy. With the individual portions of Mr. SWINBURNE'S Paper we do not propose to deal, lest we anticipate what those who will ultimately discuss it may be intent on saying; but the opportunity of calling attention to the rate, direction and limitations of the development of commercial electrolysis, is too good to be let slip together, and it is with these aspects of the question that we are more particularly concerned.

Taking these in their order, it appears that with regard to the rate of development there is just now a greater activity than there has been for sometime past. This activity must not be measured by the number of new processes that have made their way into the records of the Patent Office, the columns of the technical press, or even into the enterprising hands of the company promoter, but rather by the degree of intelligent investigation that has been allotted to known methods to determine the condition of their successful working and their economic value, and to the demarcation of the limits within which fresh attempts may best be made. Prospecting is eminently useful, and, indeed, indispensable, always provided that the prospector be skilled in his craft. Judged by this standard the rate has been one that should gratify all but those constitutionally impatient. We have seen, for example, the production of aluminium, both by means purely electrolytic, and by other methods employing electrical energy in ways more disputably so, advance from the position of a hopeful suggestion to that of a fact sufficiently definitely accomplished to serve as the basis of a flourishing industry. Even more striking has been the growth of the application of electrolysis to the refining of copper, which has increased, as we recorded the other day, in the United States until the quantity thus treated is quite comparable with that treated by older processes. Less has been done in this country largely because the capital and enterprise that should have gone to its development have been lavished on a particular application of electrolytically-refined copper, which has many other difficulties to contend with than those which beset the path of the refiner pure and simple. What is needed to give the whole industry an impetus that may at once suffice to make it the only process of refining worthy of serious consideration, is the attainment of means whereby the current density, and therefore the rate of deposition, may be raised until the solution and reprecipitation of half an inch or an inch thickness of the metal, may be the work of hours or days, instead of weeks or months. Experiments in this direction have already been made by Mr. SWAN, and their realisation in practice will be of importance to the electrolytic copper refining industry almost equal to that which made it possible—the introduction of the dynamo. That the difficulty will be ultimately overcome there is no reasonable doubt; no physical reason exists limiting the successful deposition of copper to the slow formation that has been put up with hitherto, and where no physical disability exists, attainment is only a question of time. Less cheering is the account that must be rendered of such advance as has been made in the manufacture of "heavy chemicals" by electrolytic means. The prize is large enough, one would think, to stimulate inventive capacity to its utmost; but beyond a few abortive attempts to electrolyse brine or fused sodium chloride, and to displace bleaching powder with the solution obtained by submitting a solution of calcium or magnesium chloride to electrolysis, little has been done. The ill-success of the former is probably rightly attributed to the anode trouble, and that of the latter to the extremely injudicious assertions with which performances by no means remarkable have been eked out. When it is gravely reported concerning a notorious process that a compound is produced by the electrolysis of magnesium chloride which, though incapable of isolation, recognition, or reproduction by chemical means, is yet endowed with properties that remove it from the vulgar herd of bleaching agents, a doubt arises as to whether the assertion is disingenuous or merely puerile; whichever decision is arrived at, a certain want of confidence is engendered that cannot but be fatal to the industrial development of the process thus introduced and recommended. Viewing the subject, however, in its broadest light, there is no doubt but that progress, though not sensational, has been solid and considerable; nor are signs wanting that its rate is even now increasing.

With regard to the second point which we have elected to investigate, it is less easy to speak positively. The direction in which the application of electricity to chemical and metallurgical processes is tending is less definite than the fact of the progress itself. Perhaps the path at present most persistently pursued is rather that leading towards the perfection of methods of electric heating than of processes depending strictly on electro-decomposition. The electric furnace is a mighty instrument, allowing, as it does, the concentration of almost unlimited energy within narrow limits, and the results of its adoption are what might have been expected from a consideration of that property. Its potentialities were recognised by us in an article published some time ago, when nothing more than its application for a few limited purposes had been generally realised; and already it has taken its place, not only in commerce, but as a useful laboratory tool, which will soon be as indispensable as an oxygen-injector furnace. The reasons for its utility are not far to seek; when

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to the capability of producing an all but limitless temperature is added the absence of waste from the conduction of heat at high temperatures through refractory walls, and the complete absence of products of combustion with the inevitable removal by them of a portion of the very heat they have been called into existence to obtain, no wonder need be felt that attempts to take advantage of these desirable qualities are legion. Beyond the more immediate future, however, it does not appear likely that this preponderance of electric heating over truly electrolytic methods will persist. The true province of the application of electrical energy to chemistry and metallurgy is to be found where scope is given for its dirigible qualities and selective action, and these are not to be attained by any electric furnace.

Finally, with regard to the limits within which advance is practicable in the present state of our knowledge. They are set by the high cost of electrical energy as compared with that of its older rival, heat. Such other difficulties as undoubtedly exist are only hindrances and not true limits, for their removal involves no reconstruction of the order of things as we at present know them. Take for example two that we have already touched upon in another aspect. It would involve no alteration of any idea of importance if an anode were devised capable of serving in the electrolysis of sodium chloride without serious disintegration, but it might revolutionise the alkali trade. Again, there would be nothing very startling in the ascertainment of conditions under which a current density of 100 amperes per square foot could be utilised in the electrolytic refining of copper; yet it would, we submit, be of some slight importance to the refiner. But a successful plan for obtaining 90 per cent. of the energy locked up in coal, in the form of an electric current, would be an alteration of a much more revolutionary character. Then it would be almost optional whether the heat that can be got by burning coal were used directly, or converted into electrical energy, conveyed to a distance and again turned into heat on the precise spot where it was needed. There would be no question then as to whether it would be worth while to use the electric furnace, for the only possible objection to it would have disappeared, nor would manufacturing chemists hesitate to embark in the resolution of an electrolyte merely because the amount of energy required was considerable. Of such nature is the limit, and pending the attainment of the millennium that it defines we must be content to improve existing methods to the utmost extent of their capabilities, in order that their development may, upon its arrival, proceed apace.

REVIEWS.

The Alternate-Current Transformer in Theory and Practice. Vol. II.: The Utilisation of Induced Currents. By Prof. J. A. FLEMING, M.A., D.Sc., F.R.S. (London: *The Electrician* Printing and Publishing Company, Salisbury-court, Fleet-street.)

In reviewing the first volume of this work nearly two years ago,* we found much to admire and praise, much that raised high expectations for the volume which was to follow. These expectations have by no means been disappointed in the volume before us, which deals with the utilisation of induced currents. The new volume is in many ways of even greater interest than its predecessor. It begins with an account of the historical development of the induction coil, tracing it back through the researches of Ritchie, Hearder, Poggendorff, Foucault, Page, Callan, and Sturgeon, to those of Joseph Henry. His flat spirals, it would seem, rather than the earlier ring of Faraday, must be taken to be the direct ancestors of the modern induction coil. The name of Bachhoffner, who was the first to recognise the value of a divided iron core, is almost unknown in electrical work. Nevertheless, the author shows with what good right this may be claimed for Bachhoffner. He also remarked that it was Sturgeon who gave to the induction coil the general form which it has retained ever since for medical and spark purposes. Modern transformers for electric lighting date from 1878, in which year numerous British patents were applied for. In dealing with the work of successive inventors a well-deserved word of praise is given to Gaulard and Gibbs for the boldness and constancy with which they insisted on the value of the transformer methods of distribution in the face of doubt and even of ridicule. They may not have been the first; but they did a very great service to the industry by their unwearying efforts. This historical review goes on in Chapter I. for about a hundred pages, when it abruptly changes into an elementary theory of modern transformers. Chapter II. opens with distribution by transformer systems as carried out by various firms whose machinery and modes of operation are described. Amongst others the automatic regulating devices of Ganz are very fully dealt with, and several central stations erected by this firm are described in great detail. Here we come upon some inequalities in the work; for whilst the systems of Ganz, Westinghouse, and of the Metropolitan and Thomson-Houston Companies are very fully described, those of some equally deserving rivals are less fully given. The high-tension (*sic*) fuse of Ferranti is given, but not the high-tension fuse of Mordey, which has certainly some advantages. Chapter III. is devoted to central stations using alternate currents. This is an excellent chapter; but it might, if taken alone, lead the reader to suppose that central stations using continuous currents were relatively very unimportant trifles. Professor Fleming thinks (p. 337) that continuous currents cannot be used for systems of supply beyond a mean distance of one mile. In the midst of the Central Station chapter we are suddenly plunged on pages 354 and 355, into a mathematical discussion of the problem of coupling alternators in parallel. In respect of this vexed question the author appears to have adopted the views of Mr. Mordey rather than those of Dr. Hopkinson, Mr. Kapp, or Mr. Swinburne. Chapter IV., on the Construction and Action of Transformers, is by far the most valuable portion of the work, and gives useful summaries of the results obtained in the researches of Ryan, Ayrton, and others, including the recently developed methods of measuring power in alternate-current circuits. In searching it through, however, it does not appear that the author gives in any place directions by which the plain man can design a transformer that shall have any given output and percentage of "drop" and of efficiency. Chapter V. deals with electric welding and other practical uses. There are a large number of interesting and important matters with which it is impossible to deal adequately in any review. The change-over system used at Rome; the white glazed bricks employed in central stations in London; the "booster" used to compensate drop on long lines; the plan of firing devised to economise fuel on a bad diurnal load-curve; the unexpected "Ferranti-effect"; all these and many more points catch the eye as one turns over the pages.

S. P. T.

* *The Electrician*, Vol. XXIV., p. 110, *et seq.*

NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 277.*)

15. Slipping Splice.—At the spot where the splice is slipped overboard various data are ascertained with the view of correctly indicating its position on the chart, and assisting in any future repair work in that locality. As far as nautical matters are concerned, the officer on watch takes the latitude and longitude of the position, and if the repair is being effected within sight of the coast the angle between two points on the shore,

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as viewed from the ship, is accurately measured. For instance, in the repair of a break about six miles from Bonny (West Africa) in the coast cable between Brass and Bonny by the cable ship "Great Northern" (Eastern and South African Telegraph Company), the land bore 96 degrees between Calabar Point and Peter Fortis Point at the spot where the first splice was made after removal of the break. But the electrician requires to know more than the exact geographical position of the splice. He knows the type, the weight, the insulation, and conductor resistance of the few miles of cable he is about to lay in the sea, and he is also aware of any special peculiarities that may exist in it; but, in addition, he wants to know something about the conditions the cable will be subject to when it leaves the ship, and rests on the sea bed. In short, he ascertains the bottom temperature, the depth, and the character of bottom at this particular spot. The cable is almost a personality in the electrician's point of view. He is acquainted with every mile of cable laid in during repairs, and the conditions peculiar to each individual repair fasten themselves upon his mind in such a manner that, on the appearance of a fresh fault in any cable, with his knowledge of the nature of bottom, the depth, temperature, amount of slack and cross currents, he can, when he knows the locality, descend in imagination to the very spot, and say what has most probably caused it.

The subject of deep-sea sounding in connection with apparatus used in the recovery of samples of bottom is one of great interest and importance, more especially so in the investigations carried out in the selection of a route for a new cable. The details of this very interesting subject will be discussed in a subsequent chapter on the laying of cables, so that it may suffice at present to say that most repairing steamers are now fitted with some modification of the sounding apparatus first successfully introduced by Sir William Thomson, now Lord Kelvin. The chief features of this apparatus are the use of pianoforte steel wire, of about 0·03in. diameter for sounding, an arrangement to brake the drum in proportion as the weight of wire payed out increases, and a small steam engine for heaving in the wire after a sounding. By means of the brake action, which, in the modern improved machines is automatic, the weight of the sinker and wire payed out is nearly compensated for, so that the drum in paying out revolves only by a slight excess of the weight of wire over the back pull of the brake. On the sinker touching bottom, the drum is immediately brought to a standstill by the brake, when the measurement of the depth can be read off by the number of revolutions made. Without the gradually increasing brake action the difficulty was to know when the sinker had reached bottom, as the drum continued to revolve after this had occurred, owing partly to the weight of the wire and the momentum acquired. But this difficulty vanished with a closer observation of the behaviour of the wire in descending. On this point Mr. Edward Stallibrass, in his exhaustive Paper on "Deep Sea Sounding in Connection with Submarine Telegraphy," read before the Institution of Electrical Engineers, in November, 1887, says, "If a fair rate of paying out is maintained, by means of a sufficiently heavy sinker, and if necessary by diminishing the brake power, there is no difficulty in detecting when bottom is struck. This is observed by the sudden diminishing of the speed at which the wire runs out. With practice it is easy to distinguish between this and any slacking due to movement of the ship." The sinker, which commences to descend at a speed of about 300 yards per minute, gradually slackens down to half this speed at 2,000 fathoms. For depths exceeding this the weight of the sinker is usually about 60lb. Various devices for automatically detaching the sinker on touching bottom have been patented, to which we shall refer later. The manufacture of the steel wire has recently been improved, lengths being now obtainable up to 7,000 fathoms, so rendering unnecessary any joins in the wire.

A simple automatic attachment to a sinker for bringing up specimens of bottom is shown in Fig. 49. The cup-shaped jaws are kept apart during descent by two little levers mounted on spindles, whose bearings are in the side of the gun-metal cups. The brass stem supporting the jaws screws into a bush in the interior of the lead sinker, as shown, and a stout spiral spring bears down on the top of the jaws, to close them instantly the levers fall. This occurs on touching bottom, when the impact tends to open the jaws a little wider, and the levers instantly fall; the jaws then snap together, trapping between them a sample of the bottom. In this particular design, introduced by Messrs. Johnson and Phillips, the sinker is heaved up with the sounding wire.

In the measurement of temperatures at the bottom of the sea, specially designed thermometers are employed to resist the great pressures met with. In Sir William Siemens' electrical thermometer the resistance of a coil of insulated wire immersed in a bath on board is, by adjusting the temperature of the bath, made equal to that of a similar coil sunk in the sea. When the bridge balance shows the resistances of the coils equal the temperature of the bath is that of the sea below. In the Miller-Casella registering thermometer, a modification of Six's thermometer, the effect of the sea pressure is prevented from acting directly upon the mercurial column by enclosing the latter in a second tube of glass. This jacket is three parts filled with spirit, and the air exhausted from the remaining part, so that contraction of volume can take place in it without affecting the mercurial column. This form of thermometer has been most successful in various expeditions, and with some modifications, to which reference will be made in a further portion of this series, is now universally used. The temperature at the bottom of the sea is what is required to be known, and the thermometer must therefore register the bottom temperature without being affected by passing through warmer or colder strata of water on its way down or up. Mr. J. Y. Buchanan, F.R.S., a member of the scientific staff of the "Challenger" expedition, and since connected with some cable route surveys, has devised the "Mercury Piezometer" which registers the temperature at the greatest depth to which it is

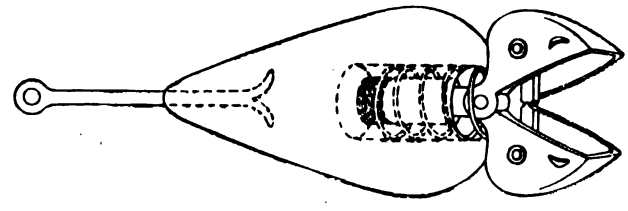

Fig. 49.—Sinker, for bringing up specimens of sea bottom.

lowered. The capsizing thermometer of Negretti and Zambra also effects this very well in moderate depths. Temperatures at the bottom of all the great oceans closely approach freezing point, the Atlantic at 2,000 fathoms depth being 36° F., the Pacific being a degree or two lower. The Mediterranean Sea is in this respect an exception on account of its comparatively shallow connection with the Atlantic through the Straits of Gibraltar. The temperature even at the greatest depths in this sea is never below 55° Fahr.

The condition of low temperature is most favourable for submarine cables. The conductivity of the copper conductor and the resistance of the insulator are both thereby increased. The great pressure of sea water on the ocean bed also increases the insulation resistance, most remarkably so in the case of gutta-percha. On this head, information obtained at the time of laying a cable is most valuable in subsequent repair work in the same waters. After submersion the contractors carry out daily tests of the cable for one month, and amongst other determinations they measure very carefully the resistance of the conductor making all corrections for temperature of testing room. On comparing this with the resistance of the cable as measured at the standard temperature of 75° Fahr. in tank at the factory, the mean temperature of the sea in which the cable is laid is arrived at.

The nautical position of the splice is subsequently marked on the cable chart with the date attached; but the electrician also requires to know the distance of the position from the shore, as measured along the cable, which is a different thing. This he finds by a resistance test of the conductor before the new end is spliced on, the man on shore earthing cable during test. After the result is corrected for temperature of sea and perhaps checked by a return test from shore while ship earths, the distance of the position in knots

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from shore is obtained by dividing the result in ohms by the number of ohms to the knot at standard temperature, which is known.

The arrangements for slipping the finished splice overboard depend upon whether paying-out is to be done over the stern or the bows. Diagrams representing the deck of the vessel in plan, showing the position of the cable and gear in each case, are given in Figs. 50 and 51. When it is intended to pay out over stern, as in Fig. 50, the end of cable in tank before splicing is led aft through a set of brake clamps, over drum, under dynamometer pulley and over stern sheave, whence it is passed, as shown in the illustration, outside ship and brought up on board again over one of bow sheaves. When a sufficient length for splicing is hauled on board the cable is stoppered at bows, and the splice completed in the manner described. The end of the other part of the cable is similarly stoppered, and these fixed stoppers at the bow baulks are used to slip or ease away the cable through until the length of bight inboard is as small as possible. Another stopper is then attached at each side of the bight just outside the sheaves, each stopper having a round thimble in it. A drum rope, say 3½in., is then led from picking-up drum and threaded through the thimble, and the end made fast to bullards near fish davits.

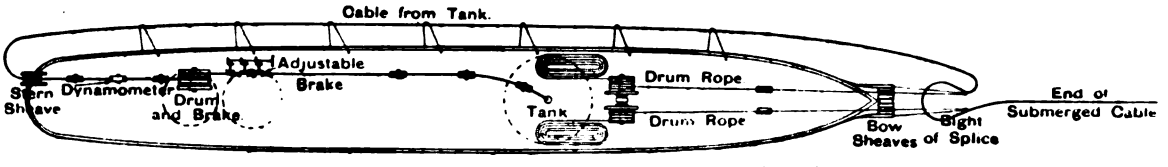

FIG. 50.—Slipping Splice. (To pay out from Stern.)

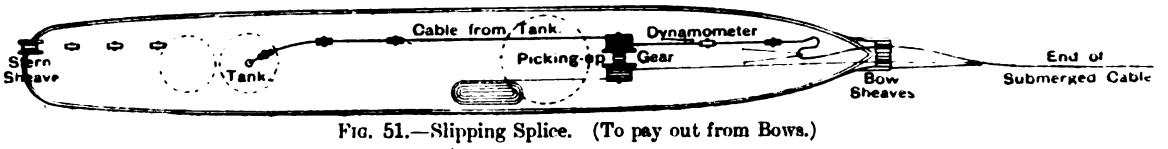

FIG. 51.—Slipping Splice. (To pay out from Bows.)

This being done on each side of bight, as shown in sketch, the drum ropes are heaved tight to take the strain while the fixed stoppers are removed. A heaving line is then passed through the bight to guide it while riding over sheaves, and the cable is then lowered by slacking away on both drum ropes. When the bight has passed clear of the sheaves, the heaving line is run clear of cable, and when sufficient length of drum rope is payed out the ends attached to bullards are let go, and the ropes run clear through the thimbles of the stoppers

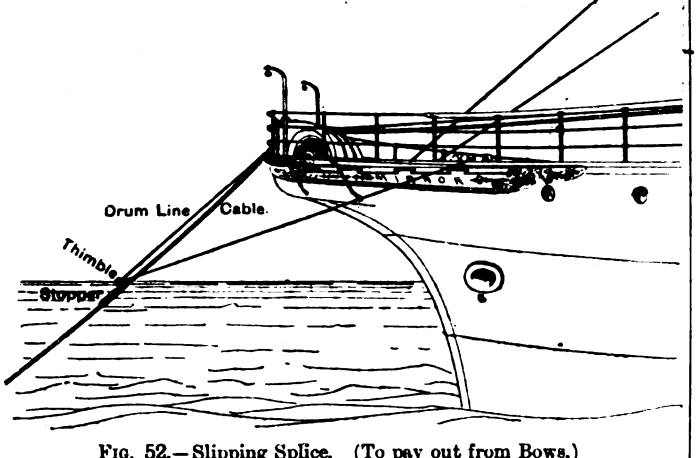

FIG. 52.—Slipping Splice. (To pay out from Bows.)

fastened to cable. Along the ship's side, at convenient distances, are placed men with hand slip ropes, the bights of which suspend the cable, as shown in the figure, and as the strain comes on them they are let go in rotation. By this means the strain due to weight of cable as it sinks is checked, and does not come suddenly upon ship's stern. Should the wind and current come from the right direction during this operation nothing more than the above procedure is necessary, but if otherwise a stopper and thimble is previously put on cable immediately over ship's quarter, with a drum rope rove through thimble, and fixed in such a manner as to be able to take the full strain on the cable before it reaches the propeller. The rope is then slacked away gradually while ship is manœuvred into a position in which the strain takes cable clear of the propeller. This done the cable is in position over stern sheaves ready for paying out.

The set of brake clamps for paying out alluded to above and indicated in the sketch, are semi-circular blocks placed alternately on a table, between the surfaces of which the cable passes. The blocks on one side are fixed and on the other side movable together by a shaft with bevel pinions turned by a hand wheel. As the brake is applied the movable blocks move towards the fixed ones, forcing the cable between them to take a slightly zigzag or wavy course, which rapidly imposes a resistance to its speed of movement. This is found a most necessary adjunct to the ordinary brake on the paying-out drum, when long lengths of cable have to be payed out from tank, as in laying new cables, but is not necessary in the paying out of short lengths in repair work.

When paying out is to be done over ship's bows the end of cable in tank is taken forward over picking-up drum and under dynamometer pulley previous to splicing, the seaward end being heaved in to allow a sufficient length for making splice and then stoppered inboard at bow baulks (Fig. 51). When the splice is complete, a stopper is put on outside ship, and cable lowered away, as described above, until the strain comes upon the cable inboard, when the rope is slipped, and everything is ready to pay out. This operation is shown in Fig. 52, the bows of the steamer shown being that of the cable ship "Mirror" (Eastern Telegraph Company). The bow baulks in this steamer are fixed in a position agreeing with the outline of the cutwater, giving a snug and yacht-like appearance to the bows. The bow gear is the design of Mr. W. J. Johnson.

(To be continued.)

THE BATTLE OF THE "PHASES."

It has not been until recently disputed that the three-phase motor has an advantage over the ordinary Tesla (two-phase) motor, in so far that it possesses a more constant and uniformly rotating magnetic field. Mr. J. F. Kelly, in the *Electrical World* for April 16th, calls this advantage into question, and in a mathematical article attempts to show that the reasons advanced by Herr Dolivo-Dobrowolsky for the superiority are not simply insufficient, but non-existent; and that, consequently, if such superiority really exists, some other explanation must be found for it. In replying to this attack, Herr Dobrowolsky, in the *Electrical World* for July 2nd, in the first place states that such authorities as Mr. Gisbert Kapp and Prof. Ferraris have acknowledged the correctness of the conclusion that the greater the number of phases employed the more constant in strength the rotating magnetic field becomes. He then proceeds as follows:—

"I do not care to go into mathematics, but will limit myself to ordinary logic. If the motor had an absolutely constant and uniformly rotating field, it should develop during every moment absolutely the same mechanical energy, and should,

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therefore, also consume during every moment absolutely the same amount of electrical energy. The electrical energy which is delivered to the motor is in watts. With a *sinusoidal current* the watts also follow a sine law. On the other hand, if we have two alternating currents which differ in time by one quarter of a phase the waves of the watts which the motor receives differ also by one-quarter of a period. The energy which the motor receives is the sum of the watts of the two currents. But the sum of the two sine curves of the watts is not constant, and varies by about 40 per cent. It follows from this that the motor receives energy from the line which is not constant from one moment to the next, but which pulsates. As long as the mechanical inertia of the motor is not considered in the theory of the motor, it may be assumed that the work delivered by the motor is likewise not constant from one moment to the next. Whether this is to be explained by saying that the field intensity alone pulsates, or that the speed of rotation of the field oscillates, is quite immaterial. In any case we see that the speed and torque of a two-phase motor cannot be as uniform as it would be if the field was rotated mechanically and had a permanent magnetism. The more phases we use the nearer will the watt curves come together, and the more uniform will be the electrical energy which is applied to the motor and the mechanical energy that is given out by the motor."

Referring to non-sinusoidal currents, Herr Dobrowolsky states that it is useless, with the view of obtaining greater uniformity in torque, to design the machines for currents of some special shape, for a particular form of current curve can be developed for one output only. "There has, doubtless, been sufficient proof published in the electrical literature that the sine form is the only one which is stable and easily produced. If by reason of some improper proportioning of the dynamo it produces any other currents (for instance, pointed waves), it will always be possible in a motor to have a uniform rotation of a constant field, if one will only use very many phases. As three-phase currents require no more leads than when two-phase are employed, the use of three phases is not accompanied by any disadvantage, and I am sure that the two-phase current now belongs to the past. If one wishes to obtain more phases with three leads, one can use the method that I suggested a year ago, and called 'double-linking,' which has been described in a number of Papers, and is patented by me. There has also been much said against the properties of the three-phase current motor. It is claimed that the motor cannot be started loaded. How do these critics know this? I have always claimed in my writings and Papers that the motors which I have built developed a large torque at starting, which statement is based on *experience*. If there still exists a doubt, there remains only for me to request the unbelievers to examine my motors. Then I will take pleasure to connect large as well as small motors with a brake, and start them with the brake applied; this I did repeatedly before I made the published statement. Mr. Stanley and many others claim that 10 and even 20 H.P. transformers will be necessary for a 2 H.P. rotary field motor, because such a large exciting current is required. I published in the *Elektrotechnische Zeitschrift* complete data of tests made with a 2 H.P. motor in April, 1891. Those who will study this article will find that the motor when running unloaded has a phase difference of about 72 degrees between the current and the voltage, but when delivering 2 H.P. this was only 28 degrees, and with 3 H.P. 22 degrees. With normal load, namely, 2 H.P., it consumed 1,830 true watts, as compared with 2,079 apparent watts. It is plainly stated that with a load of 2 H.P. there were 9·9 amperes in each of the three currents at 70 volts. Therefore one does not require a 20 H.P. transformer for running such a motor, but only one which is built for three times 9·9 amperes at 70 volts, namely, for 2,079 watts; this would equal only about 2·8 H.P. In the same article I call especial attention to this very small phase difference, and state the ratio

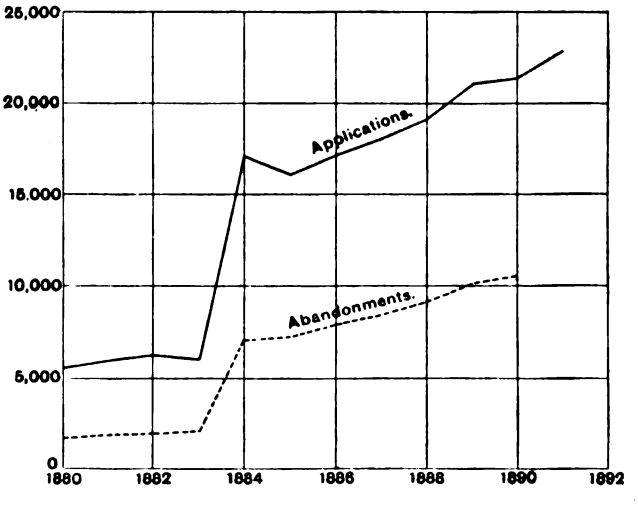
$$\frac{\text{1,830 true watts}}{\text{2,079 apparent watts}} = \cdot 88 = \text{cosine of angle of lag,}$$

is a very favourable one for such a small motor, aside from the total efficiency of about 80 to 81 per cent. at full load, and 75 per cent. at half load, and the possibility of delivering 4 H.P. for a short time without great sacrifice in economy."

Mr. Kelly replies, in the *Electrical World* for July 16th, that the figures given by Herr Dobrowolsky, while they show a high degree of merit in the three-phase motor, are not sufficient to prove it better than the two-phase motors built by the Westinghouse Company. A proof is given that the power supplied by two quarter-phase currents, such as those used to drive a Tesla motor, is the same at every instant. The correctness of the proof, however, depends upon the assumptions that the currents follow the sine law, and that the two circuits are symmetrical, so that the same phase difference between the volts and amperes obtains for each circuit. Accompanying Mr. Kelly's article is one by Mr. C. P. Steinmetz, who shows that it is a fundamental law that in any symmetrical system of polyphase currents, whether two, three, or any number of phases are used, the sum of the instantaneous values of the watts supplied by the different circuits is constant. He states that it is for this reason that a polyphase system can be so easily transformed from one number of phases to any other. These advantages are, however, as fully present in the case of quarter-phase currents as for the three-phase ones; and Mr. Steinmetz considers that the only advantage of using the latter lies in the fact that the greater the number of phases the less will be the objectionable effects consequent on deviations of the current from the true sine law. The success of the three-phase system in Germany is attributed to the low frequency of the currents employed, and the prominent attention it has received to the accidental connection with the Frankfort-Lauffen high-pressure experiments.

THE INCREASE IN PATENT OFFICE BUSINESS.

In the report of the Comptroller-General of the Patent Office on the proceedings which took place in his Department during 1891, the general business compared with that of previous years as far as 1884 is given in the form of tables. These tables show a steady increase in the number of applications, but these are accompanied by a formidable number of abandonments.



We have consulted the statistics of former years, and have prepared a diagram showing the remarkable effect of the Patent Act of 1883. Prior to 1880 there was a slow rise in the number of applications, while the abandonments were nearly constant at about 2,000 per annum. In the year preceding the new Act there was a decided falling off in applications, due, of course, to patentees who were in no particular hurry, and who preferred to wait for the lower fees; but it is to be observed that the abandonments were hardly affected. Then comes a rush both of those who had been holding back and of the thousands who were encouraged to try their luck; and this was followed by a falling off of about 2,000, after which the applications have increased rapidly, and show as yet no signs of exhaustion. The abandonments, however, have risen from about one-third to one-half. It must be remembered that there is, as it were, a lag between the two curves, the majority of the

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abandonments dating nine months after the corresponding individual applications.

We take this opportunity of reminding our readers that the reduction in patent renewal fees proposed by Mr. Goschen in his recent Budget will, by order of the Board of Trade, come into operation after September 30th prox. The following is the new scale compared with the old:—

Fifth year's	tax	£5	instead of	£10.
Sixth	„	£6	„	£10.
Seventh	„	£7	„	£10.
Eighth	„	£8	„	£10.
Ninth	„	£9	„	£15.
Tenth	„	£10	„	£15.
Eleventh	„	£11	„	£20.
Twelfth	„	£12	„	£20.
Thirteenth	„	£13	„	£20.
Fourteenth	„	£14	„	£20.

The fees payable on enlargement of time for paying the above taxes will also be reduced as follows:—

Not exceeding	1 month,	£1	instead of	£3.
„	2 months	£3	„	£7.
„	3 „	£5	„	£10.

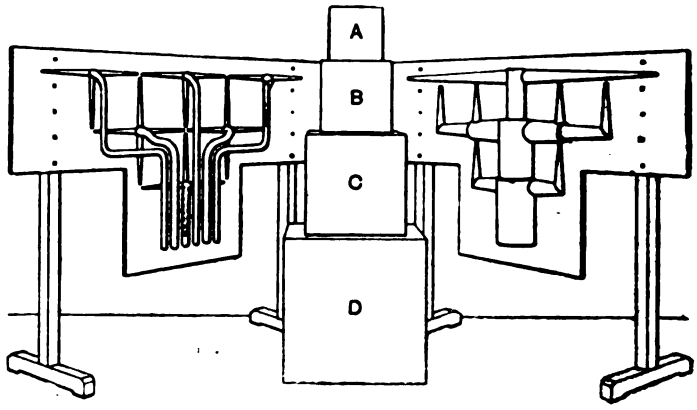
The above reduced scale will be applicable to all patents in force. The result is a total reduction of Government fees on a 14 years' patent from £154 to £99, *i.e.*, £55.

ELECTRICAL MODELS FOR LAW COURTS.

We referred some little time ago to the elaborate models which had been specially constructed for the purpose of assisting counsel's explanation of the principal points in the Edison feeder-patent case, which had then recently occupied the attention of the American Law Courts. Mr. W. J. Jenks, of the Edison Electric Light Company of New York, has been good enough to send us some excellent photographs of these models.

The apparatus consisted of an ingenious and instructive arrangement of glass and metal pipes, rotary pumps, and turbines, running on horizontal axes, representing respectively mains, dynamos, and motors or lamps. The pipes contained fluid, in which coloured globules could no doubt be arranged so as to render its circulation plainly visible. Glass gauges, representing voltmeters, indicated the hydrostatic pressure at different parts of the circuit by the height at which the water stood in them. The fall of pressure over a circuit, as influenced by the amount of current flowing, was thus very clearly exhibited.

These models promise to be particularly valuable in making plain the somewhat complex actions which take place in the three-wire and similar compensating systems. In the middle or "neutral" conductor of a three-wire system, for example, the liquid might be made to flow in one direction in one part of its length, in another direction in another part, and, perhaps, in an intermediate position it would remain at rest. Mr. Jenks tells us that other models are being made, and the idea, although no doubt very valuable for merely illustrating electrical phenomena in law courts, should also be of great educational value in schools and technical colleges, where, of course, the limitations of the hydraulic analogy would be carefully pointed out.



A. This Cube represents $\frac{1}{150}$th of Mass of Copper Conductors required for the nine City Blocks shown in Models containing 8,640 Lamps of 16 c.p. by Three-Wire Feeder System. B. Ditto, by Two-Wire Feeder System. C. Ditto, by Three-Wire Tree System. D. Ditto, by Two-Wire Tree System.

Amongst these "object lessons" intended for the enlightenment of the legal mind were a number of boards on which were mounted models, showing the bulk of copper required in the different systems of distribution. We reproduce a sketch of these particular models.

These designs are due chiefly to Mr. W. J. Jenks, and the details were worked out by Mr. A. E. Kennelly, of the Edison Laboratory, Orange, N.J.

THE JENKIN CLIP FOR CONNECTING HOUSE SERVICE WIRES.

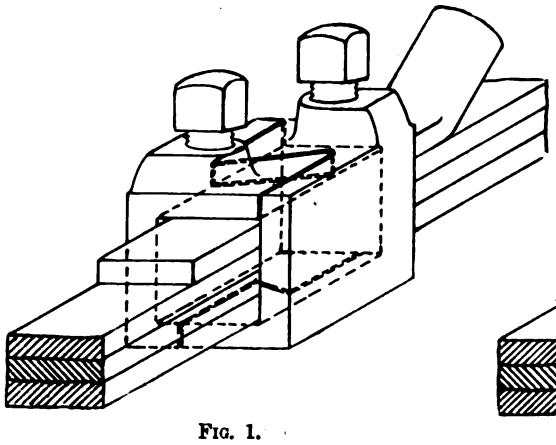


Fig. 1.

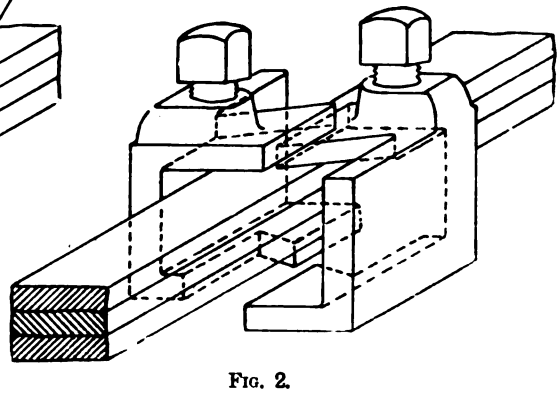


Fig. 2.

A handy form of clip connection for connecting house service wires to copper strip has been designed by Mr. B. M. Jenkin. In Fig. 1 the clip is shown in place clamping down a house service end on to the three flat strips forming the main. The clip is in two pieces, and so shaped that when the fourth strip is in it cannot fall off, even if the screws should be loose, while, when the extra strip is taken out, one half of the clip can be pushed down below the other and pulled off sideways, as shown in Fig. 2. The clip thus makes a purely mechanical connection, one which can be made anywhere along the length of strip, which cannot fall apart, but which can be disconnected with the greatest ease, and without risk of short-circuiting between one line of strip and the next line parallel to it.

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THE PROBLEMS OF COMMERCIAL ELECTROLYSIS.*

BY J. SWINBURNE.

It would be idle to attempt to go over the whole subject of the technical applications of electrolysis, as, although this development of industry is of very recent growth, it is already so extensive that many of its branches demand evenings devoted exclusively to their discussion. My object is, however, to take a sort of bird's-eye view of the subject, and, if possible, to try to foresee the directions in which others must seek for future developments.

There is a very general feeling that there is a mine of untold wealth in the application of electricity to metallurgy; but chemists are not generally electricians, and electricians are seldom chemists. It seemed, therefore, advisable to bring the Paper before this Institution, in the hope that it will result in a discussion; and if it leads to the expression of the views, both of electrical engineers and manufacturing chemists, and to a further approach to common ground, our time will be well spent.

However puzzling the theory of electrolysis may be, for commercial purposes it may be regarded as involving no mystery. In fact, broadly speaking, we may disregard the electrical side of the question, and look upon electrolysis as a method of oxidising and reducing, and nothing more. It must be remembered, however, that there are often many ways of oxidising the same substance. For instance, a sulphide may be oxidised into a sulphite or sulphate, or sulphur may be liberated. Electrolysis does not always afford the means of oxidising in the particular manner desired. A very large number of the processes employed in chemical industry consist merely in oxidising and reducing, special conditions being arranged to suit the particular substance being operated upon. Once we take this broad view, all we have to consider is, "Which of the oxidising and reducing processes in use in chemical works can we advantageously replace by electrical methods?" In many cases electrical methods are impossible; in others they are more expensive than those at present in use; but it is hardly too much to say that in an enormous number electrolysis is destined to play a leading part in the near future.

Take, for instance, the case of reduction. This is almost universally effected by means of hot carbon, and at first sight it seems unlikely that it could pay to burn the carbon under a boiler, and get a small percentage of the energy back in the electrical form, and to utilise that portion alone. It must be remembered, however, that the methods of reduction by burning carbon are themselves exceedingly inefficient, and, moreover, they very often give impure products. By means of electrolysis, however, it is frequently possible to secure metals of the highest purity by direct processes. Before going further, it will be wise to form some idea of the cost of electrical energy in, say, a large chemical works. Of course "cost" is a loose term; we might calculate it from the cost of coal and labour and sundries; or we might add interest and depreciation, rent and superintendence. In all cases in estimating the cost, further additions have to be made for standing charges, advertising, profits, maintaining patents, &c. It is unnecessary to trouble ourselves about definitions of cost, for if it is stated how the figures are obtained, the selling price can be worked out and comparisons can be made.

Suppose a plant is put up to give a million watts, it will be found that if the plant is taken as running day and night, including Sundays, and if the best engines, with modern dynamos, are employed, the cost comes out about 0·25d. per kilowatt-hour. This figure includes interest and depreciation of engines, boilers, and buildings, and coal, labour, and petty stores; but does not include rent or salaried superintendence. This figure will appear ridiculous to those accustomed to London central stations; but that is because central stations work under the most disadvantageous conditions possible, while a chemical works has everything in its favour.

Oxidation and Reduction.

Oxygen.—The first obvious application of electrolysis is the decomposition of water. In an acid solution platinum or lead anodes are necessary; platinum is expensive, and lead takes a high electromotive force, so it would be best to use an alkaline solution with iron electrodes. Allowing 2 volts as the pressure required, the cost comes out at 5s. 7d. per 1,000ft. for the oxygen. The hydrogen is taken as valueless. As the output in oxygen must be small, we must take a much higher figure than the farthing per kilowatt-hour—in fact, it would be safer to double the price and say 11s. 2d. To find the selling price we must allow for packing in cylinders, and add all the trade charges, which will probably bring the price up to something like 15s. per 1,000 cubic feet. The retail price of Brinn's oxygen is 2d. per cubic foot, so there would appear to be a very large margin.

Alkali.—We come next to a subject which has already absorbed an enormous amount of labour and thought, and that is the production of caustic soda and chlorine from common salt. The Leblanc and Weldon process is exceedingly complicated and very costly; and as by simply electrolysing salt, costing about 15s. a ton, chlorine and caustic soda can be produced, it seems, at first sight at least, most strange that electrolytic processes have not replaced all others within the last few years. Assuming that the process works, let us first form a rough idea of its probable economy. With suitable vats, and a reasonable current-density, we may take it that 3 volts is a liberal allowance. For the ton of 70 per cent. caustic soda we have—

	£	s.	d.
Electrical energy	2	15	0
Salt	1	2	6
Lime	1	3	0
	£5	0	6

For £5 we have thus obtained a ton of caustic and 1½ ton of bleaching powder. We have allowed nothing for the cost of vats, for labour at the vats and in handling, or for evaporation of causticised liquor. The ordinary caustic liquor after causticising is quite weak, but electrolytic caustic can be made into a strong lye. On a small scale I have produced lye with 30 per cent. caustic. To do this the brine is electrolysed and then stirred up with more salt, and so on; the process being repeated several times. Strong caustic is a good conductor, so this method is good from that point of view as well as from that of saving in evaporation. Evaporation with a Yaryan should not come to more than a shilling or two a ton extra. It would doubtless be safe to say that, taking this way of estimating the cost, a ton of caustic and a ton and a-half of bleach should be made for £6. This allows an enormous margin for expenses and for profits. This method of estimating is very rough; and unless a new process worked out in this sort of way comes out with an enormous margin, it is not likely to be worthy of serious consideration. On looking into it further, it will generally be found that when all the details of expenditure which will be necessary in practice are added, the margin, if it still exists, is too small. In fact, a new process must look marvellously good on paper to be really worth anything when tried commercially. Electrolytic soda and bleach seem to have an excessive margin, however, and we have to see whether there is any other weak point.

I believe the difficulty, and the only difficulty, lies in the anodes. Process after process is brought out, and each claims to have solved the problem of electrolytic soda by the use of some new arrangement of the porous partition, or by some other detail which can hardly make all the difference between success and failure. The various processes make a little excitement for a time, and then disappear, I believe because the anodes are destroyed.

Of course none of the ordinary metals can be used as anodes, as they are attacked at once. Platinum is generally supposed not to be attacked by chlorine; but I find that it is slowly eaten away. I would like to hear this confirmed or denied by others, for it is a very important point. On the one hand I find experimental anodes eaten away; on the other, we hear of platinum anodes being used extensively in the electrolysis of chlorides. Of course, in the manufacture of such a cheap commodity as soda, the capital invested in platinum anodes would be prohibitive; and the least waste of metal would lead to ruinous expenditure. The next material to consider is carbon. In 1882 Bartoli and Papasogli pointed out that carbon was attacked when used in any solution which evolves oxygen. Without knowing of their work, I found the same thing by a series of experiments carried out in 1883. In those days it was tacitly assumed that carbon with peroxide of lead could be used in the ordinary secondary batteries, without any fear of local action. Though carbon does not seem to combine with chlorine during electrolysis, I find that it is always attacked, even in a solution of salt. I have tried every kind of carbon I can think of, and the result has always been that the anode was corroded. I do not mean to say that carbon is eaten away at a rate at all corresponding to that with which the soda is formed; in comparison the corrosion is slow. It must be remembered, however, that a very slow corrosion makes carbon anodes useless when the products are cheap.

Carbon is also troublesome mechanically. It is difficult to make good contacts with it, especially when there is chlorine about. Large carbon plates are also expensive. Mr. Greenwood overcomes this last difficulty by electro-plating one side of a number of comparatively small plates, and then soldering them to a plate of type metal. The type metal is not exposed to the solution anywhere, else it would be attacked by the chlorine. By this means he produces a large carbon anode with a good metallic connection.

Peroxide of lead seems to present a solution of the problem. Unfortunately, however, peroxide of lead is reduced by hydrochloric acid; and it seems to be impossible to electrolyse salt without producing some free acid at the anode. Some specimens of lithanode I tried were attacked; I do not know, though, whether the inexhaustible ingenuity of Mr. Fitzgerald has produced any special make which will stand traces of free acid. I am inclined to think, therefore, that progress is barred in this direction solely by

* This Paper will be discussed at the Institution of Electrical Engineers at one of the first meetings after the recess.

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the want of a good anode. If this is the case, there is a fortune awaiting the inventor who can find something which will act as an anode in a solution of common salt.

I have tried electrolysing sodium sulphate. There is not the same margin here. You get hydrochloric acid as a by-product, instead of chlorine, so that the Weldon process would still be necessary; and the sulphuric acid would have to be concentrated every cycle, in order to act on the next batch of salt. This process would, in fact, save the black ash part of the soda process; and, like all these methods, would demand carbonic acid to make soda crystals. Of course, this last is not a serious difficulty, especially if quicklime is needed to absorb the chlorine. In this case I tried lead anodes, when, to my surprise, the small traces of chloride left in the sulphate corroded the lead anodes.

Paper-makers use large quantities both of caustic and bleach, and they recover soda and causticise it on their works. It would therefore be an enormous advantage to be able to produce caustic and bleach direct on their own premises. I do not know if the presence of salt would interfere in any way with the action of caustic in the grass or straw boilers, but should think not. By making the caustic on the spot, a saving is effected in the processes otherwise necessary. There would be no need to concentrate the lye, or to fish out the salt that may be present. Caustic drums and carriage would be saved; but, of course, against this there may be carriage of salt. The importance to paper works is so great that it is almost a question whether it would not pay to face the corrosion of the carbons, and to arrange vats so that the anodes can be easily replaced.

In the Hermite process the chlorine is not given off, but a hypochlorite is formed. Of course, in this case caustic soda cannot be made. For paper works especially it is obviously cheaper to supply lime and get bleaching powder and caustic, than to make sodium hypochlorite only. This may, however, depend on the anodes. Platinum anodes are used in this process, and it seems to be the case that platinum is not attacked in an alkaline chloride. If this is so, it is possible to produce hypochlorite of soda, but not caustic and bleaching powder. The Hermite process is apparently commercially successful. Magnesium chloride is generally employed in the Hermite process, but I have been told that salt is now used. It has been said that electrolytic hypochlorites, especially of magnesium, have more bleaching power than the ordinary bleaching powder. Of course, a sodium, or any other hypochlorite, may be formed which has twice as much of its chlorine available, when compared with bleaching powder; but this is merely an apparent gain, as it takes twice as much electricity to produce the hypochlorite. Messrs. Cross and Bevan, however, hold that the bleaching power of these compounds is not as determined by arsenious acid. They maintain that the fibres to be bleached contain some ketones or other, and these ketones absorb some of the available chlorine, especially when provided by bleaching powder; that the hypochlorite of sodium and of calcium waste available chlorine on the useless work of chlorinating these ketones, while magnesium hypochlorate devotes its whole attention to honest bleaching. Of course, if it is slightly easier to oxidise the colouring matters than to attack the ketones, it may be the case that a hypochlorate of a weak base, like magnesium, may be able to bleach, but not to attack ketones. It would then be better than the hypochlorate of calcium, or especially sodium. These matters are better left in the hands of such authorities as Messrs Cross and Bevan. They make out, also, that electrolytically prepared magnesium hypochlorite is best. This seems very strange. Of course it would mean that some other salt is really formed. The properties of a salt cannot depend on the method of its preparation, and there is no magic in electrolysis.

Potassium Chlorate.—The manufacture of potassium chlorate is carried out by electrolysing a hot solution of the chloride. The chlorate is thenformed instead of the hypochlorite. This process is carried out on a large scale at Vallorbes, in France, under the direction of M. Gall-de-Montlaur. It is stated that they make a ton a day, 24 H.P. hours yielding 2·2lb. The power is supplied by a waterfall, so the chlorate should be very cheaply made, if the anodes are absolutely free from corrosion. Platinum anodes are employed.

The Electrolysis of Fused Salt.

Many inventors have been at work on electrolysis of fused salt. At first sight this also seems most simple. Salt is cheap, and is fusible, and therefore all that has to be done is to melt it and electrolyse it, getting sodium at one pole, and chlorine at the other. The sodium could be sold at a very low price for making aluminium, and for amalgamation in gold extraction, and can, of course, be converted into caustic soda or crystals as desired. Consumers of caustic would buy the metallic sodium, and would add water, thus obtaining pure caustic. The margin of profit in this case is apparently enormous.

The difficulties are, however, very serious. In the first place, sodium chloride boils at a very little above its melting point. The result is that the sodium is obtained mixed with large quantities of salt. Melted salt is by no means a convenient substance to handle. It acts on many kinds of clay, so that ordinary fire-clay crucibles cannot be employed. Chlorine at a temperature corresponding to a red heat is also troublesome to deal with. It is said that chlorine will not attack a dry metal, so that iron can be used for the containing vessel. Most patentees describe vessels of iron with porcelain where insulation is necessary.

We now come to the anodes again. As there is no oxygen present, it would seem as if carbon might be used. Patentees always mention carbon anodes. Retort carbon is eaten away, and so are electric light or artificial carbon rods.

It seems strange that carbon should be attacked, and it would be well for these experiments to be repeated, to make sure that there is no error. Of course carbon is the only hope. Whether the chlorine is dry or not, metals are eaten away with great rapidity. The anodes are corroded chiefly at the surface. In addition to these troubles, the theoretical quantity of sodium is not obtained. Some people have supposed that there is a sub-chloride formed, and that sodium is really not a monovalent metal. This is rather an extravagant notion. I do not know why both sodium and chlorine should not be soluble in the fused chloride without forming any definite compound. So many workers have been unsuccessful with fused salt, that it looks as if there were some insuperable obstacle in the way; and it is questionable whether the ground is worth any further labour.

Electrolysis of Fused Soda.

Castner has recently proposed to produce sodium cheaply by the electrolysis of fused caustic. The temperature is to be high enough to fuse the caustic, but not high enough for the sodium to decompose the fused hydrate forming oxide. Whether this process has had any success commercially, I do not know.

Aluminium.

The extraction of aluminium has long been an important problem. The old method was to replace aluminium in its chloride by means of sodium. This involves the manufacture of metallic sodium, and of the anhydrous chloride of aluminium. The anhydrous chloride cannot be obtained by evaporation of its solution, as the solution gives off hydrochloric acid, and leaves alumina; otherwise the anhydrous chloride would be quite cheap. The price of sodium has been reduced recently by the Castner process, but the extraction of aluminium by ordinary means is still so expensive that electrical methods can compete.

It seems to be impossible to deposit aluminium from any of its solutions, so fused salts have to be employed. The electrolytic processes differ in detail only. The electrolyte is cryolite, or a solution of alumina in cryolite. If cryolite is electrolysed, aluminium is deposited, and fluorine is presumably evolved at the anode, which is made of carbon. I have not seen any account of how the fluorine comes off. Yet in some processes it is stated that cryolite is electrolysed by itself. In the Minet process the solution of oxide is employed, and aluminium is deposited, and the anodes are burned away by the oxygen, giving off, according to some accounts, carbon dioxide, but probably the monoxide in fact. The chief difficulties in the electrolysis of cryolite solutions are due to the cryolite itself, as it attacks all the substances commonly employed for making crucibles. It is, therefore, usual to use cast iron to make the containing vessels or vats, and to heat the electrolyte by electrical power from the inside.

Minet uses iron vats, and arranges a shunt current, which makes the vats to some extent cathodes, so that they are not attacked by the electrolyte. Presumably fluorine is soluble in fused cryolite, and attacks iron. By making it a cathode it is always coated with aluminium, so that any fluorine is taken up in dissolving off some of this aluminium. The importance of preventing the corrosion does not lie so much in the slight saving of iron as in the avoidance of any deposit of this metal in the aluminium. The great difficulty is to get the aluminium pure, and any trace of iron reduces its value for most purposes very greatly. Minet reduces the melting point of the electrolyte by the addition of common salt In the Hall process, carried on at Pittsburg, the electrolyte is practically the same. Calcium fluoride is used to mix with the cryolite, or calcium chloride. The Kleiner, and, I believe, the Hall, processes are carried on in England. The processes have so often been fully described elsewhere, that I need not discuss them at any length here. There is still a great demand for cheaper aluminium; and there is much to be done in making it pure. Aluminiuum has a strang affinity for silicon, and small percentages of silicon and iron are generally present, and are very deleterious.

Magnesium.

This metal is closely allied to aluminium, and is similar with regard to its anhydrous chloride. There is not the same demand for it, as either it does not give remarkable alloys like those of aluminium, or they have not been investigated. It is said to be made on the Continent by electrolysing the double chloride of magnesium and sodium or potassium obtained from the mother liquor

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after evaporating sea water. The double salt can apparently be rendered anhydrous without the formation of much magnesia.

Zinc.

Proposals have been made to deal with zinc ores electrically. The blend is to be roasted into sulphate, and the solution dissolved and electrolysed. A great difficulty arises in the deposition of the metal. It comes down in trees. Kiliani proposed to use high-current densities, holding that zinc then comes down in the reguline state. Watt prefers to use acetate of zinc as the electrolyte; and alkaline solutions, such as zincate of soda, have also been proposed. I am not aware that zinc has been deposited commercially. Similar processes have been proposed for dealing with the silver-zinc alloy produced in the Parkes or Karsten desilverisation process.

Lead.

So far, little has been done in the way of dealing with lead ores electrically. It has been proposed to make anodes of galena, and to work with lead nitrate as electrolyte, but I have not heard that any such process has been carried out successfully. It is hardly likely that it could, as lead forms troublesome trees in acid solutions. Anyone who has worked with solutions of such salts as lead nitrate would be inclined to give up all hope of obtaining anything like a reasonably compact deposit of lead.

The extraction of silver from lead by the Pattinson process is very cumbrous and roundabout, and is, of course, expensive. Keith started a works in America for desilverising electrolytically. He used a solution of sulphate of lead in sodium acetate as electrolyte. Though the Keith process was brought out some ten years ago, it does not seem to have come into general use. The deposit of lead even from such a solution as sodium plumbite is very bulky and spongy, and is difficult to deal with, as it is apt to decompose water and oxidise spontaneously during handling.

Gold and Silver.

Greenwood and others have proposed to make chlorine electrolytically for catching gold by the chlorine process. As this is exactly the same problem as making bleaching powder, the same difficulties have to be overcome; so it need not be discussed further.

Mr. Crookes's sodium amalgam for making the mercury ready to seize any particles of gold, and to keep it from getting "sick," can be replaced by making the mercury itself the cathode. It is questionable whether this would be worth while, as the sodium amalgam is very convenient.

Mr. Crookes has recently brought out other electric gold processes. He finds that the particles of gold become amalgamated, and collect and get caught in the mercury, if the stamped quartz is washed in a weak solution of a mercury salt, under the influence of an alternating current of small frequency. It is difficult to see how the alternating current works. Unless the current-density or the resistance of the electrolyte is something fabulous, there cannot be any current in the small particles of gold, as the minutest polarisation would make all the electricity flow by the electrolyte, and not by the little pieces of gold, even though they are very much better conductors.

(To be continued.)

ON THE EFFICIENCY OF TRANSFORMERS.*

BY M. VON DOLIVO-DOBROWOLSKY.

Since the distribution of electricity by high-pressure currents has lately again come into prominence, thanks chiefly to the practicability of the transmission of power by means of alternating current and the "Drehstrom," it has become necessary for us to know something more about transformers. I do not mean to imply that too little has been written about transformers, or that there has been too little experimenting; on the contrary, a great deal may be found regarding the possible distortions of the current curve owing to Foucault currents, and we hear of very exhaustive experiments as to whether hysteresis, in spite of constant magnetisation, does not really vary slightly according to the load on the transformer. But as to how this apparatus is to be proportioned in order to work economically—which is the main idea the electrical engineer must keep before him if he proposes to give the transformer a really practical and efficient form—little enough is to be found amongst the mass of written material. This has given rise to many entirely false principles, ideas, and prejudices, which have come to us from early times, and are now difficult to eradicate. I am not, as will be apparent to you, by any means an adherent of all the Swinburnian deductions; but I must, to be just, allow Mr. Swinburne the merit of having paved the way towards the practical consideration of transformers. I cannot, of course, in this Paper propound a complete theory of what I hold to be the proper construction of transformers, but I will select just a few heads and communicate them to you.

I have already briefly described my fundamental theory of the alternating current at the Electrical Congress held at Frankfort. I said: The magnetism (reckoned as number of lines of force) rises so high that the electromotive force induced in the apparatus, added to the loss of potential, becomes equal to the exciting potential. If B be the number of lines of force, p the number of periods, N the number of turns on the coil, and E the so-called mean electromotive force* in volts, we get the known equation,

$$E \times 10^8 = 4\,p\,N\,B.$$

If, however, firstly, the loss of potential be very small, as is the case with transformers and motors; secondly, the number of alternations remain constant; and, thirdly, the apparatus be ready wound (that is, the number of turns be fixed), the above formula becomes simplified, as follows:—The magnetism is equal to the terminal potential multiplied by a constant. In other words, the potential is a measure of the magnetism, and *vice versâ*.

This formula is applicable generally, without regard as to whether the coil generates current or receives it, or whether the current be strong or weak (the latter statement is, of course, only correct in respect of a small loss of potential); and, further, whether the magnetism be generated from some external source, or induced by the current itself flowing through the coil. Neither has the value of the magnetic resistance any effect. If the windings and alternations remain constant, the magnetism for a certain potential is always the same; and it may be said that magnetism and potential mutually balance each other. As a consequence of this, every essential difference between induction, self-induction, mutual induction, &c., ends.

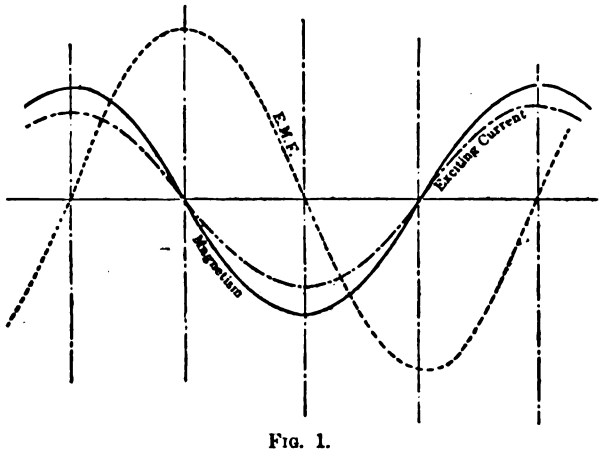

FIG. 1.

As the electromotive force is proportional at any moment to the rate of change in the number of lines of force, the latter being greatest at the moment of inversion of polarity, we have the further important rule, that the phase of the electromotive force (or potential) lags behind the phase of the magnetism by a quarter period. (*See* Fig. 1.) So long as the current is only a magnetising current, or merely has to furnish the proper number of ampere-turns without performing further work, it cannot be otherwise thought of than in connection with the lines of force which it induces; the phase of the current then coincides with the phase of the magnetism. If we examine the curve in Fig. 1 more closely, we see that the current flows half the time *with* the potential, the other half *against* it. Our coil is, therefore, half the time an apparatus absorbing energy, and half the time an apparatus generating energy. On the whole, therefore, the current neither delivers nor absorbs energy; it is "wattless." This "wattless" current, since it only serves to create a magnetic field without doing any work, we will call "exciting current." If, on the other hand, current is passed through a non-magnetic apparatus, that is, one in which resistance only has to be overcome and no magnetic field exists or is created, heat is developed all the time, according to Joule's law; the current pulsates, then, in synchronism with the terminal potential. This is the real "watt current." Neither the "watt current" nor the exciting current exist as such alone; they are invariably combined, for every current creates a magnetic field, and there are neither non-inductive resistances nor coils without resistance, and an ideal soft iron without residual magnetism has yet to be discovered. Every alternating current consists, practically, therefore, of two currents, the watt current and the exciting current; while we must add together as two forces acting at right angles to obtain their resultant. Fig. 2 shows the addition of the exciting current O C_1 to the watt current O C_2, where O C is the resulting

* A Paper read before the Electrotechnic Society of Berlin, March 22, 1892.

* The effective electromotive force is, as is generally known, some 10 per cent. higher than the mean.

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current as measured in practice, and is then the angle of lag of the resultant current behind the terminal potential or electromotive force. With high potentials or with rapid alternations the electrostatic capacity, or the electrostatic field, must not be neglected. Here again we have a wattless so-called "charging" current, only that in this case the terminal potential is a quarter of a period behind the current; or, what is practically the same thing, the current is accelerated a quarter period ahead of the terminal potential. Strictly speaking, therefore, every alternating current resolves itself into three currents: the exciting current, the charging current, and the watt current. I shall in my remarks to-day leave the capacity phenomena mostly out of the question, as they only come into play in special cases.

A great deal may be adduced already in respect of transformers from the above-mentioned formulæ; and I take the following by way of illustration.

(1.) The magnetism of a transformer remains almost absolutely constant under all loads; it decreases only in proportion as the loss of potential in the primary, that is, the exciting coil increases; and then only 1 or 3 per cent. It therefore follows again that hysteresis, that is, the demagnetising work in the iron core, is

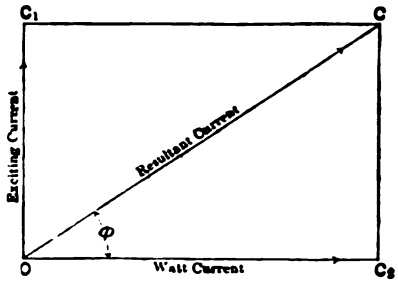

Fig. 2.

an almost constant quantity; at any rate, this change is of no importance in considering the efficiency of the transformer, since it is practically of no importance whether we assume that the transformer consumes 2·00 or 2·02 per cent. of the full load as exciting current.

(2.) In an unloaded transformer the watt current is very small, as only the demagnetisation of the iron and the minimum potential loss in the copper call for an expenditure of energy.

(3.) The current of a transformer on open circuit consists, for the most part, of the wattless exciting current, and is, consequently, dependent upon the magnetic resistance. The resistance of the iron necessitates more or less ampere turns for the magnetism required by the terminal potential; the given or assumed number of turns will then give the maximum ordinate of the exciting current.

(4.) Upon plotting the diagram shown in Fig. 2 it will be found that, owing to a small current, the exciting current causes a considerable lag of the resultant current. This lag and the strength of the resultant current are greater the greater the ratio of the magnetic resistance (that is, the necessary number of ampere turns) to the primary turns. In the case of transformers having many turns per unit difference of potential (that is, with much copper) the exciting current, for reasons which will be shown later, and for the above reasons, is smaller, even when small magnetic resistance is not specially taken into consideration.

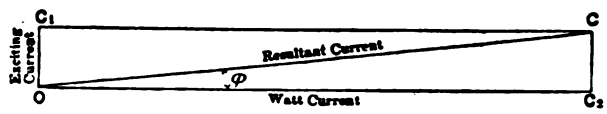

Fig. 3.

(5.) If a transformer is loaded, and especially by incandescent lamps or other approximately non-magnetic resistances, only that component which I have called the watt current arises; and the phase difference, therefore, diminishes. Fig 3. shows that, even if the exciting current amounts to as much as 10 per cent. of the maximum working current, we have at full load practically no difference between the resultant current and the watt current; that is to say, between apparent and real watts. In fact, the angle here is only 6deg., the cosine of which is 0·985, and consequently the difference between the real current and that determined by measuring the watts is only 1½ per cent. In most transformers the exciting current is far below 10 per cent., so that with incandescent light distribution the lag in the transformers need not be taken into account as all.

(6.) If, as in the case of open-circuit transformers, the exciting current is large compared with the cross section of the copper, the Joule loss even at no load is not to be neglected; this results in a larger watt current component than would ensue from hysteresis losses alone. Such, for instance, is the case with Mr. Swinburne's "hedgehog" transformer, where the exciting current amounts to about 30 per cent. of the maximum watt current. Nevertheless, its consumption of watts at no load amounts to only 1 per cent. of its full output.

(7.) If a transformer has a load of coils, or similar magnetic apparatus, it will deliver an exciting current principally. The consequence is that only the exciting current rises, and there is no diminution of lag. The diagram in Fig. 2 is always applicable, and the transformer connected between the generating station and the point of consumption will only add its own exciting current and its own watt current required for the internal losses.

(8.) It is possible by augmenting the magnetic resistance of the transformer—as, for instance, by means of the insertion of paper between the joints of the iron (Fig. 4)—to increase the exciting current in order to compensate for the inverted phase difference caused by the electrostatic capacity of the circuit. In this way the current generated in the dynamo may be reduced to a minimum in comparison with the consumption of watts.

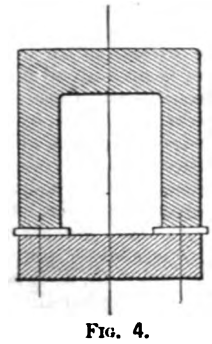

Fig. 4.

Having sketched in the above remarks the theory of the transformer according to modern ideas, I proceed to the question of design. A best method for transformer calculations can no more be given than in the case of dynamos. As in the latter case, the best thing to do is to sketch on paper a number of transformers, make your calculations, and then select that which best meets the case in question. If we consider certain leading principles from the very beginning, we may by practice develop the instinct so far as to rapidly hit upon the desired dimensions without wasting too much paper. Curves are very valuable in the case of the design of a transformer intermediate between two stock patterns. Having sketched a transformer, we submit it to the following most important calculations. In the first place, we have to see that the copper resistances are sufficiently small, which is an easy matter. Then, if no alterations in the copper cross-section are necessary, we calculate the energy consumed in reversing the polarity of the

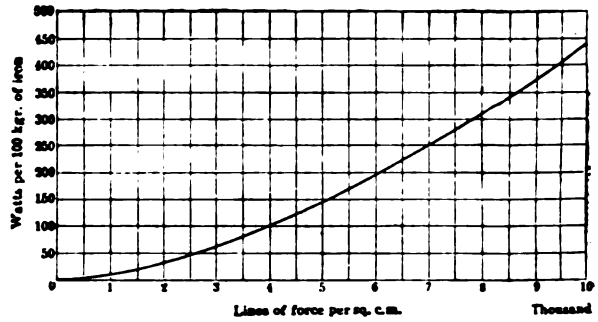

Fig. 5.

iron. It is one of the most difficult problems in transformer construction to get little loss of energy in the iron and at the same time to provide sufficient room for the winding. The energy absorbed by polarity reversals depends chiefly upon what is now called hysteresis; but to hysteresis loss must also be added the Foucault current losses, which are never entirely eliminated; these are, however, very slight with properly laminated iron; at least, I have found it so from a study of the curves of total iron losses with various magnetic densities and various frequencies. The watt loss by hysteresis with a certain magnetic density is just proportional to the mass of iron, and is also nearly proportional to the number of alternations (a very slight increase is due to Foucault currents). So far as the dependence of the hysteresis loss (Polwechselarbeit) upon the magnetic density is concerned, I have almost invariably found a pleasing accordance with the law enunciated by Mr. Steinmetz, of New York, as well as with Prof. Ewing's curve. I should say at once that the numerical factors vary according to the quality of the iron. From an examination during the last two years of nume-

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rous samples of sheet iron of the Allgemeine Electricitäts Gesellschaft I have got values which were 1·2 to 2·5 times greater than those given by Prof. Ewing. Although better kinds of iron are not excluded, yet I believe that in general practice Prof. Ewing's figures should be multiplied by 1·6 to 1·7. The curve in Fig. 5 shows us the loss per 100 kilogrammes in a moderately good iron with 80 alternations (40 periods), and with various magnetic densities. The figures of this curve are 1·7 times greater than those of Prof. Ewing. A fairly proportionate difference may be assumed for frequencies, not differing too widely from the above.

(To be continued.)

THE BRITISH ASSOCIATION COMMITTEE ON ELECTRICAL STANDARDS.

The following communication has been made by Dr. Oliver Lodge to the above Committee :—

In view of the hoped-for presence of Prof. von Helmholtz and other distinguished foreigners at this year's meeting of the British Association in Edinburgh, it will probably be recognised as suitable to take up and continue the discussion on new electro-magnetic units for practical purposes, which was begun last year at Cardiff. I therefore beg to contribute the following notes, and to conclude by moving some resolutions.

One great fact brought into prominence by the practical development of electricity is the analogy or reciprocity between the electric and the magnetic circuit, and this is the fact which it behoves us to emphasise in the naming of fresh units. The magnetic circuit has as yet no authorised names applied to it. The electric circuit is well provided, but perhaps one or two improvements can be made.

(1.) The Electric Circuit.

The first point on which I consider that practical men would do well to insist is that names shall be given to the complete things dealt with, rather than to mere coefficients. Thus of all units with which they are concerned there can be no doubt but that *volt* and *ampere* are the most prominent. These are the active things with which electrical engineers have to deal, and these are the things for which meters exist on every wall in an electric lighting station. The ohm, or unit coefficient of resistance, is comparatively academic in character ; it is a constant of a coil of wire or of an underground lead, it is nothing vivid and active. The engineering use of the term ohm is mainly in connection with insulation and other high resistances ; for large conductors the equivalent "volt per ampere" is perhaps more often used. It is the drop of potential which a given conductor entails for a given current that is of real interest to an engineer, and it is this of which in large leads he consciously thinks.

A 6-ohm conductor means one that drops 6 volts for every ampere that is sent along it. If you send 3 amperes along such a line, the potential at the far end is 18 volts below that at the near end. The clear realisation of this fact would be almost aided by the complete title, 6 volts per ampere, instead of the abbreviation, 6 ohms. Nevertheless, the name ohm is in common use and hence may be assumed useful.

A still more useful name, however, for good conductors would really be the reciprocal of an ohm—the ampere per volt. Suppose this called a mo, as Sir W. Thomson once suggested, then a cable of 20 mos would be one that conveyed 20 amperes with a drop of 1 volt. A thousand-mo cable would convey 500 amperes with a drop of half a volt, and so on. It is more directly practical to think of the amperes conveyed per drop of voltage, than of the drop of voltage per ampere. I believe that some authorised name for unit conductance would be welcomed.

Units of Inconvenient Size.

The authorised name "coulomb" for unit quantity is barely used by engineers, who are content with ampere-hour ; thus proving that what is needed in practical units is not so much a consistent decimal system, as a set of units each of practicable magnitude.

Farad.

The effort after consistency has resulted in the useless "farad" ; and this should be a lesson not to try and fix units of unreasonable size. The C.-G.-S. units already exist as a consistent system ; the only objection to them is that they are of unpractical size. The whole object of devising a practical system of units was to have things of every-day size to deal with. The volt, the ampere, and the ohm satify this condition. The coulomb, the farad, and the watt do not. Already they have practically given place to the ampere-hour, the microfarad, and the kilowatt.

Considerably more progress would have been made in knowledge of ordinary capacities if the microfarad had been called the farad, so that easy submultiples of it would have been available to express the capacity of Leyden jars, and such like things. The capacity of an ordinary jar would then have been a few millifarads, and a microfarad would have been the capacity of a short bit of connecting wire. I ask whether this change would introduce serious confusion even now. I think not. Nobody cares the least about "coulombs per volt," and so there is no sense or use in the present farad. Telegraphists would surely soon consent to drop the useless prefix micro ; and the factor of a million is too great to render doubt possible as to what was intended, even in the transition stage. It ought to be regarded as essential to have the practical unit somewhere not hopelessly away from the middle of the range of probable multiples and submultiples.

Coulomb.

A coulomb again is almost useless as a synonym for the ampere-second ; it is so easy to speak of ampere minutes or ampere hours. If the name coulomb could be set free from its present superfluous meaning it could usefully be applied to the electrostatic unit of quantity, which wants a name. Teachers would find it convenient at once, and in the apparently imminent line of development engineers might find it useful before long. It is the charge on a two centimetre sphere at a potential of 300 volts (or on a one foot sphere at 20 volts). The capacity of the two-centimetre sphere would be $\frac{9}{10}$ of a (new) microfarad.

Watt.

Lastly with regard to the watt. The name volt-ampere is almost as good as the name watt, especially since the watt is also one joule per second.

Both names, watt and joule, are not really wanted by electricians, to whom their co-existence is rather confusing. I believe it would be more convenient to use the term watt in the sense it gets so frequently used now, viz., energy, say a volt-ampere hour ; in which case a kilowatt would be synonymous with the present Board of Trade unit.

The rate of working, or power, could then be expressed in a rational and unforced way as so many watts per hour or so many volt-amperes. It is much more natural to give a name to a definite thing like a quantity of energy, than it is to give it to a mere rate of working. The latter is instinctively felt to need a reference to time ; just as a velocity unit has not been practically found to need a name, being quite simply expressible in feet per second or miles per hour : and even when a name has been given, like "knot," instinct constrains people to practically get rid of it again by speaking of knots per hour, just as we find "kilowatts per hour" already often used in electrical workshops. I suggest, therefore, that the present watt is too small, that it is sufficiently expressed by a joule per second, and that it would be more useful if magnified 3,600 times, and turned into a unit of energy.

That we should thus have several energy units—the erg, the joule, and the watt, all of quite different sizes, is no objection, but an advantage, seeing the extreme importance of energy. Such things as length, mass, time and energy demand a fair range of units. It would be tedious to express centuries in seconds.

(2.) Magnetic Circuit.

In speaking of the magnetic circuit I wish to refer back to my opening remarks concerning the electric circuit, and the class of things for which names should be found. In the magnetic circuit the only thing at present seriously attempted to be named is, in accordance with the historic parallel of the ohm, a coefficient or characteristic of a coil of wire—its coefficient of self-induction ; the unit of which has been called variously a secohm, a quadrant, and a henry.

Total Induction.

But the real active thing with which engineers are concerned is total magnetic induction, total number of lines of force across an airgap : as between the polepieces or through the armature of a dynamo, or in the circuit of a transformer. It may be called the electro-magnetic momentum per turn of wire ; or the surface integral of **B**. This total induction is in some respects analogous to electric current, and has occasionally been called magnetic current (a bad name), or "magnetic flux." It is, however, more strictly analogous to the coulomb, and its time rate of variation is the more proper representative of electric current. Its common practical name at present is "total lines," or "total induction," or "number of lines."

Now "one line" is awkward as a unit, besides being (if a C.-G.-S. line) inconveniently small. The earth, for instance, sends 4,400 such lines through every horizontal square metre about England ; through a square inch it only sends a fraction of a line. A practically sized unit of induction badly wants a name, and "henry" would have done for it very well, and have been both more suitable and more useful for the actual quantity than for a coefficient. But "henry" has already been half appropriated to the secohm, so, for illustrative purposes at any rate, I propose to use the name "weber" for the unit magnetic flux.

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Concerning the most convenient size for the weber, there is much to be said for making it 10^8 C.-G.-S. lines, though that is bigger than ordinarily occurs in practice; because then a wire which cuts one weber per second will have a volt difference of potential between its ends. Or a coil of 20 turns through which the magnetic induction changes at the rate of one weber per second will have an E.M.F. of 20 volts induced in it. The average E.M.F. in such a coil, spinning 30 turns a second, and enclosing a maximum total induction of one weber, is 600 volts.

This is the dynamo use of the unit; the following is the motor use:—A wire carrying an ampere and cutting a weber per second, does work at unit rate, viz., one joule per second.

Probably the simplicity of all this compensates for the rather unwieldy size of the unit. A strongly magnetised piece of iron may have 20,000 lines to the square centimetre; so a weber could occur across a narrow air-gap half a square metre in area. The earth gives an induction of about one weber through every 23,000 square metres of England, or 100 webers per square mile. The earth induction through a horizontal square metre is 44 micro-webers, so with micro- and milli-webers the range would be fairly covered; though a smaller weber would have been better if it had been equally convenient as regards the volt. The pull between two parallel surfaces joined by a weber is $10^{16}/6\pi$ dynes, or 400,000 tons. A milli-weber gives less than half a ton pull; and a micro-weber less than half a gramme.

Because of the property that the voltage excited in a circuit is equal to the webers cut by it per second, a weber might be called a sec-volt. It is equal to a secohm-ampere-turn; that is to say, if a single turn of wire can have a self-induction coefficient of one secohm, it will excite a weber of induction for every ampere passing through it.

[Such a circuit in the form of an anchor ring would be enormous, something like a mile across; but it could be made in the form of a solid cylinder of best iron ($\mu=2,500$), with an axial perforation for the wire, and 80 metres long. If a secohm coil has n turns, then an ampere passing through it excites only $1/n$th of a weber; for, since every turn encloses the induction, the latter is effective n times over, and so the induction coefficient is n times the induction per ampere, or n^2 times the induction per ampere turn.]

No name is needed for intensity (or density) of induction (B), for that can always be expressed in webers per unit area. [For instance, strongly magnetised iron, with say 10,000 lines to the square centimetre, has one-tenth of a weber per square foot, or 0·7 milli-webers per square inch.] And there is a practical gain in thus leaving the specification of area open, for it enables British units of length to be employed in measuring air-gaps, yokes, cores, and pole-pieces. So long as dynamo dimensions are commonly expressed in inches, there is no serious objection to specifying induction in fractions of a weber per square inch or per square foot.

Magnetomotive Force.

Now, consider the magnetic analogue of the volt; the unit of magnetic potential or magnetomotive force. By this is understood the line integral of the magnetising force H, the quantity $4\pi nC$, the step of potential once through and all round the circuit of a coil. It is a quantity most important in practice, and requires a name.

Mr. Heaviside has suggested the name "gaussage," as analogous to voltage; and, if this were adopted, the unit of magnetomotive force would be the gauss. The intensity of magnetising force would be the gauss-gradient, or drop of gaussage per centimetre; no special name is needed for the unit of this quantity H.

The common practical unit of "gaussage," at present is the ampere-turn, and this has several advantages. It may, however, be found better to make some convenient number of ampere-turns into a gauss; for instance, the C.-G.-S. unit of gaussage would be $4\pi/10$, or, 1·2566 ampere-turns. If that were adopted as the gauss, the horizontal component of the earth's magnetic intensity about here would be, say, ·18 gauss per linear centimetre.

But this unit, whether the C.-G.-S. unit or the ampere-turn, is very small. The step of potential all round a single ampere-turn is only equivalent to a vertical step of about two centimetres in the earth's field. Nevertheless, in spite of its smallness, the ampere-turn as practical unit of gaussage will probably commend itself by reason of its simplicity. Let us see how it works out.

Reluctance.

The ratio of gaussage to the induction excited by it is a quantity characteristic of the magnetic circuit, and called its reluctance or magnetic resistance. This is the quantity $l/A\mu$ for simple circuits, or $\Sigma\, l/A\mu$ for complex ones; it is unfortunately not constant for any but air circuits. This constitutes one difficulty of naming its unit satisfactorily, else it might be expressed as so many "gilberts" or "sturgeons" (analogous to ohms). It is, however, fairly constant under many common conditions of practice, and it can always be expressed as gausses per weber; and perhaps this way is sufficient.

A magnetic circuit with unit reluctance is one that requires one gauss to induce in it one weber.

Permeability.

Permeability (μ), analogous to electric conductivity, would be measured by the webers induced through unit cube of the material between whose faces there is unit fall of gaussage. It has been suggested (by Prof. Perry) that the permeability of air had better be called $4\pi\times10^{-9}$. But the whole electro-magnetic system of units is based on the μ for air being called 1; so it would be rather confusing to change that. Moreover, it would be a retrograde step to affix another incorrect value to the constant μ, instead of waiting and trying to find out what its value really is. It is better to adhere for the present to the existing table of permeabilities, and to use whatever constant factor may be needed in order to turn $l/\mu A$ into practical units of reluctance.

Permeance.

But the reciprocal of reluctance, or the webers induced per gauss, may be the more instructive thing to attend to and name; just as conductivity is often more directly interesting than resistance. This reciprocal ratio, $\mu A/l$, has been called "permeance," and that is not a bad name for it; it is proportional to the inductance of a single-looped circuit. Permeability is the permeance of unit cube of the material. Permeance is the webers induced per unit drop of gaussage. Permeability is the webers per unit area induced by unit gauss gradient.

The permeance of the magnetic circuit enclosed by a solenoid of wire is the same as its appropriate self-induction-coefficient divided by 4π times the square of its number of turns. The C.-G.-S. unit of permeance (or of reluctance) is that of a centimetre cube of air, and is not a bad-sized unit. But it is inconsistent with the weber as 10^8 and the gauss as a single ampere turn. One of the three must give way.

On the whole, I have no hesitation in suggesting that the derived unit (that of permeance) must give way, and be taken as $4\pi\times10^7$ C.-G.-S. units, in order to harmonise with the other two, as already defined.

The fact is that the great size of the weber renders a small gauss desirable, in order that their product may not represent too large a quantity of energy. For instance, if 1 C.-G.-S. unit were taken as the unit of permeance, the weber being fixed at 10^8, then the gauss would also be 10^8, and the gauss-weber would be 10^9 joules, or nearly 300 Board of Trade units; which is far too much. Whereas if the unit of permeance is fixed high, and the gauss kept small, then the energy corresponding to a gauss-weber may be moderate. Thus with 10^8 C.-G.-S. as weber, and an ampere-turn as gauss, their product is only $10^9/4\pi$ ergs, or $100/4\pi$, or about 8 joules; which will be useful in energy considerations connected with the heating of transformers.

I therefore propose, in order to retain the ampere turn as unit of gaussage, that the permeance of a cylinder of material of length l and area A be reckoned as $\mu A/l$ multiplied by $4\pi\times10^7$, if dimensions of the cylinder are measured in centimetres; μ being its ordinarily tabulated value with air=1. If dimensions are measured in inches, then the permeance of a cylinder will be $\mu A/l$ multiplied by $4\pi/2{\cdot}54\times10^7$, that is by about $\frac{1}{2}\,10^8$. The unit of permeance thus suggested is immensely big, and it requires a name of which easy sub-multiples could be formed. A slab of iron one centimetre thick, and with its $\mu=2,500$, would need an area of five square metres in order to have unit permeance; but a micro-unit would be possessed by an air-gap a millimetre thick and less than a decimetre square.

Proposed Resolutions.

1. That the unnecessary prefix "micro" be dropped before the word farad, and that the farad be defined afresh as 10^{-15} C.-G.-S. electro-magnetic units of capacity.

2. That the name "mo" for the unit of conductance, or the ampere per volt, be recognised and adopted. (Every *mo* in a cable enables it to carry an ampere with a drop of 1 volt.)

3. That the ampere-hour be recognised as a convenient practical unit of electrical quantity.

4. That the volt-ampere-hour be recognised as a convenient practical unit of electrical energy, and be called the watt. (It equals 2,640 foot-pounds, or a trifle over a foot-ton.)

5. That the present Board of Trade unit be called a kilowatt.

6. That the ordinary unit of power be a kilowatt per hour. (It equals about four-thirds of a horse-power, more accurately 1000/746 H.P.)

7. That it is convenient to retain the name joule in its present sense of a volt-coulomb, or ten million ergs, for use in the science of heat; since heat-capacities are conveniently expressed in joules per degree; and it will be handy to remember that a volt-ampere generates one joule of heat per second.

8. That the name coulomb be affixed to the electrostatic unit of quantity (for academic purposes).

9. That a name be given to unit magnetic flux or total induction, and that the name weber is suitable.

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10. That the most convenient size for the weber is 10^8 C.-G.-S. units or "lines" (since the rate of change of this through a circuit is equal to the induced voltage).

11. That a name be given to unit magnetic potential or magnetomotive force, and that the name gauss is suitable.

12. That the handiest size for the gauss is one ampere-turn.

13. That a name be given to the ratio of the weber to the gauss, or unit of permeance, or self-induction per turn of wire. [If the above resolutions were adopted, this unit would be $4\pi 10 \times {}^7$ C.-G.-S. units, or $\frac{1}{8}$ secohm per turn.]

14. That intensities of field be expressed in gausses per unit length, and densities of induction in webers per unit area (leaving the length or area unit open for practical convenience to arrange).

No doubt many of these recommendations have been made before. Mr. Preece has often urged the change of farad, so that I hope there will be no difficulty about that. I find that my magnetic suggestions are very similar to those suggested by Prof. Perry in his modified letter to the Committee as published in *The Electrician*, Vol. XXVII., p. 355 (July 31, 1891), and received there with approving editorial comments. The accordance between our suggestions is satisfactory, and makes it likely that they are such as engineers may be satisfied with and be willing to adopt. I need hardly say that I lay no stress upon the particular names here proposed. In choosing them I have been influenced by such trivial considerations as the selection of a monosyllable to correspond with volt, and a dissyllable to correspond with ampere or coulomb.

[With regard to Prof. Perry's footnote concerning college instruction and use of C.-G.-S. units, I suppose systems of teaching differ; but a senior student ought to be taught to deal with concrete quantities in so familiar a manner that no possible admixture of units can be any puzzle to him, nor involve anything worse than a little tiresome arithmetic.]

Mechanical Units.

There are several quantities in dynamics beside the joule and the watt for which brief names would be advantageous. I do not propose to discuss these fully now; but the present opportunity might be utilised by agreeing to at least one unit, that of pressure, viz., the "atmosphere," which might be defined as 10^8 C.-G.-S., or dynes per square centimetre, and stated to be equal to the pressure of a column of mercury 75 centimetres high at a specified temperature. The inconvenient pressure, 76 centims., might be spoken of as a Regnault atmosphere. I believe that a smaller unit of pressure, for instance, the micro-atmosphere or "barad," might also be usefully named. These pressure units will be useful for expressing energies per unit volume also, and the "barad," or whatever other name is decided on for the erg per cubic centimetre, is of reasonable magnitude for many purposes.

SOME SEPARATIONS BY ELECTROLYSIS.*

BY E. F. SMITH AND D. L. WALLACE.

This Paper contains an account of work done at the University of Pennsylvania, in continuation of the authors' experiments on electrolysis, which have already been published (*Ann.* Chem. Pharm., 13, 417, and *Proc.* Chem. Soc. Fr. Inst., 3 20), which showed that a perfect separation could be effected by the electrolysis of a solution of the double cyanide of gold. The experiments recorded were undertaken in order to determine the effect of the presence of an excess of potassium cyanide. The temperature was found to have an important bearing on the rate of deposition of the gold, and the authors reserve the study of this for a future investigation. In the case of arsenic, the presence of a large quantity of potassium cyanide hinders the deposition of the gold, and on increasing the strength of the current arsenic is deposited with it. If, however, the solution is in about the following proportions, viz.: 10ccm. chloride of gold solution (=0·1240grm. gold), 10ccm. arsenic solution (=0·1000grm. arsenic), and 0·75grm. potassium cyanide in 150 water, results accurate enough for all ordinary analyses are obtained, and the deposit is free from arsenic. Similar results were obtained in the case of molybdenum, and of tungsten if the tungstic acid was first dissolved in potassium hydrate, and then added to the gold solution. The separation of gold from osmium, and of the latter metal from cadmium, silver, and mercury, is also readily effected in a corresponding solution; but in the case of cadmium, if very accurate results are required the amount of cyanide of potassium must be reduced. Since the deposition of gold was found to be checked by the addition of caustic potash to the bath, while that of silver was unaffected, this appeared to afford a means of separating these two metals, but experiment showed that they plated out together from a mixed solution. In the case of cadmium and nickel, however, the addition of caustic potash enables a separation to be effected electrolytically. The electrolysis of a solution of gold in ammonium sulphide gave too low results, and an attempt to separate gold from tin in a similar solution failed. The currents employed are described as liberating from 1·8 to 2 ccm. of mixed gases per minute, but the temperature and pressure are not stated.

* *Berichte*, Vol. XXV., pp. 775—782.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

New York, *July* 22, 1892.

The Electrical Utilisation of Water-Power in California.—A remarkable power plant is now in process of construction in San Antonio, South California. The plant is located in the San Antonio Cañon, where there is a minimum fall of 1,300 cubic feet of water per minute, and an available head of about 400ft. The power is brought to the power station through 1,900ft. of 30in. and 600ft. of 24in. double riveted sheet iron pipe, which involves a loss of head by friction of 12ft. The laying of the pipe necessitated a rock channel 1,300ft. in length, as well as several heavy open cuts. The power station is provided with four double nozzle Pelton wheels 34in. in diameter, coupled direct to the armature shafts of the same number of Westinghouse alternating-current generators of 200 H.P. each. The wheels will run at 600 revolutions per minute. Two exciters are provided, which are also run by Pelton wheels coupled to the shafts in the same manner. The current is carried on two No. 7 bare copper wires seven miles down the cañon to a point where the lines diverge, one running to Pomona 15 miles distant, and the other to San Bernardino 26 miles, covering by the return circuit in the latter case a distance of 56 miles. By means of transformers the potentials will be raised at the generators to 10,000 volts, and the current will be carried at this pressure to sub-stations located just outside the cities, where by means of step-down transformers the pressure will be reduced to 1,000 volts, and will then be distributed for both light and power purposes. The motors used will be of the Westinghouse synchronous type.

The Niagara Falls Projects.—Not much has been heard for some time of the company that is at work preparing to utilise a part of the Falls of Niagara. It was announced last week, however, that the Canadian Niagara Power Company, which was organised to develop the power of the Horseshoe Falls in Victoria Park on the Canadian side, had already met and elected officers. The last of the exclusive privileges to develop the power of the Falls in Victoria Park, which was granted to Messrs. Shaw, Stetson and Rankine by the Park Commissioners, was transferred to the newly organized Company. Col. Shaw, who is at the head of this company, says that it is their intention to await the completion of the tunnel on the American side before beginning operations on the Canadian side. It was announced some time since that the Canadian rights had been bought up by the Cataract Construction Company, and were now under the control of the same parties, who were working on the American side. It is understood that the water wheels for the plant on the American side were selected some time ago, and will be installed by a foreign firm. The dynamos, however, have not been selected and the Company is still seeking to find the cheapest, and at the same time the best character of plant to instal for this huge transmission scheme.

Electricity at the Chicago Exhibition.—There seems to be very little news nowadays about the electric exhibits at the World's Fair. The allotment of space has not yet been made, and the work of finishing the building is going on as rapidly as possible. Now that the contract for lighting the buildings has been let to the Westinghouse Company there is considerable speculation as to what character of plant will be installed and how satisfactory the equipment will be. It is reported that the Westinghouse Company, intend to build a machine that will supply 20,000 16-c.p. lamps and several having a capacity of 10,000 lamps, and it is said to be their intention to build the 20,000 lighter to be driven by direct connection with a pair of compound engines without fly-

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wheels. Regarding the wiring for the Exhibition lighting plant, it is said that the rules require that all transformers shall be placed on the outside of the buildings, in the case of the Liberal Arts building, which is 8,800ft. wide, 1,600ft. in length, to say nothing of the height, so that it will require some very extensive secondary wiring, and the cost of secondary leads for this building alone will call for an immense expenditure on copper. Of course the General Electric Company controls the three-wire system so completely that it will be impossible for the Westinghouse Company to instal any of its lights by the use of that method of distribution.

Mr. Cyrus Field.—It is a pleasure to know that several months before his death Mr. Field presented to the Museum of Art in this city his entire collection of medals and paintings relating to the laying of the Atlantic cable. The condition of the gift was that the articles be kept together in an alcove of the Museum, and so arranged that they would be easily accessible for inspection.

GERMAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

The commercial controversy between the advocates of the alternate-current and of the battery system of distribution is at present raging as furiously in Germany as it was a few years ago in England. But there is one thing which distinguishes this German controversy from the English one, and that is firstly the mass of valuable data which is brought to light, and which up till now has been kept secret; and, secondly, the almost abusive language that is used. Some time ago there appeared a pamphlet, written by Herr F. Ross, manager of the Helios Company of Cologne, entitled, "How Shall We Build our Electric Central Stations?" The author, after some introductory remarks, went on to show how low the working efficiency of some battery stations really was, and then chanted a hymn of praise on the alternate-current system, forgetting to give any results of actual work. This somewhat impolitic pamphlet was answered a week or so ago by a very angry one from the Hagen Accumulator Works; and to the attacks of this pamphlet Herr Ross has just answered by "Once more, How Shall We Build our Central Stations?" From these three pamphlets I will try and pick out some data which may be of interest.

The works at Hagen, which manufacture the Tudor cells, have a large battery at the Barmen station, which is only a few miles away from Hagen. At this station the total efficiency as calculated from the official records of the station manager was

Before the plates had been changed (from May 1st to May 10, 1890) ..... 37 per cent.
After the plates had been changed (from Sept. 20th to Sept. 28th, 1890) ..... 55·8 ,,

At the Darmstadt station the real watt hour efficiencies were 38·6 per cent. in 1889, and 55·9 per cent. in 1890. The battery was reconstructed at the end of August, 1889, as internal short circuits had brought the efficiency down to a very low figure, which in May, 1889, is alleged to have been 16 per cent. To this the contractors answer that at Darmstadt the battery only serves as an auxiliary means for lighting the safety lamps of the theatre four times a week and for feeding a few private lamps during the late hours of the night. This objection is a sound one, for the Darmstadt station was intended for 6,000 lamps in all, and 7,000 are now connected to it; but of these nearly 1,000 are in the Ducal Palace, where they are only used for festivals, and 2,000 or so are in the theatre, which is open four times a week. The Hagen pamphlet then goes on to assert that the working efficiencies of the following stations are as stated below:—

Dessau, 1890.....	78·9 per cent.	Hanover, 1891	78·7 per cent.
Dessau, 1891.....	79·37 ,,	Kensington Court ..	85·3 ,,
Barmen, 1891.....	70·2 ,,	Davies Street	82·94 ,,

To these overpowering data Herr Ross coolly answers that the splendid results of the last two tables were obtained with Crompton-Howell and not with Tudor accumulators, and besides that the efficiency of the Barmen battery, though it was raised to 70 per cent. as an average value, was somewhat low even in some months of 1891, being only 56·85 per cent. in February of that year, according to the contractor's own showing. Herr Ross concludes by detailing the balance-sheet of the Cologne central station, as he received it from the Director of the Cologne Gas, Electric, and Water Works (Herr Francis Poly). But be the merits of the case what they may, the unfortunate fact remains that on June 28th the Barmen Central Station Committee had to vote a further 30,000 marks for a second renewal of the battery.

The report which Mr. W. H. Lindley and Herr Oscar von Miller have presented to the Frankfort Municipality with regard to the electric lighting of that fine city forms an elaborate volume. The two learned authors first of all studied the question whether continuous, alternating, or polyphase currents should be employed. Three schemes have been worked out—(i.) alternate current and transformers; (ii.) continuous current with accumulator sub-stations, the accumulators being charged directly; (iii.) continuous current with sub-stations, where the accumulators are charged by means of rotating commutators which transform alternating into continuous currents. The schemes assume a total load of 67,000 16-c.p. lamps, or their equivalent. The central station is placed near the Main. The conclusion ultimately come to is that for Frankfort the most favourable system of distribution would be the alternating-current transformer system. Herr von Miller is also working out a plan for a central station at Strasburg, which town has also invited tenders for an electric railway from the Thomson-Houston Company.

The great event of the past few weeks has been the great and unexpected reduction in the price of the 16-c.p. glow lamps from 1s. 6d. to 1s. Two or three months ago a private consumer thought himself fortunate in getting his incandescent lamps for 1s. 8d. I am not quite aware what has caused this reduction, but I think the first who commenced it were Messrs. Siemens and Halske of Berlin, and of course the other manufacturers had to follow suit. But now that the private consumer is getting cheap lamps, he is also being overwhelmed with pamphlets, filling his innocent mind with doubts and monstrosities such as 2-watt lamps, 1½-watt lamps, short life, high efficiency, blackening, increase of resistance, decrease of lighting power, &c., &c. Messrs. Siemens and Halske themselves are circulating a warning against low-watt lamps, and state that 16-c.p. lamps which require 1½ watts per candle at the beginning give only 4½ candles at the end of 55 hours, the number of watts per candle thus increasing from 1½ watts to 4½ watts.

There are central-station projects afoot at various places. First of all, the municipality of Frankfort is preparing, still preparing to make up its mind. Dresden is also trying to discover the ideally-best project for lighting the town. At Aix-la-Chapelle Schuckert and Co. have commenced building a station. At Bremen the same firm has just begun excavating the 45 kilometres of trench, into which they will place 180 kilometres of cable. At Limburg on the Lahn W. Lahmeyer and Co. of Frankfort will utilise water-power for lighting the town, which is 2 kilometres distant from the source of power.

CORRESPONDENCE.

THE DIMENSIONS OF PHYSICAL QUANTITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to my question, "W. M. M." seeks to establish a distinction between the numerical identity given in my last letter and the symbolic expression $t\,[T] = l\,[L]$, in which, according tohim, all the four symbols represent abstract quantities. The distinction is only that between a special case and a generalised expression, and there is not the least difficulty in employing the latter if it is preferred.

Thus, if a, b, x, and y, are all abstract quantities the two sides of the equation $ax = by$, can be compared. If we write $a = t$, $x = [T]$, $b = l$ $y = [L]$ (which is legitimate if [T] and [L] are abstract), we get the equation $t\,[T] = l\,[L]$, the two sides of which cannot, according to Fourier's rule, be compared. At what point does the absurdity come in?

But whatever "W. M. M.'s" way out of the difficulty may be, it must be remembered that the meaning of a symbol as used by any writer is that which he assigns to it by definition. It is beyond dispute that competent authorities have used the symbols [L], [M], [T] to indicate concrete quantities. Maxwell, for instance, states that "if we write [L] for the unit of length, that is to say, the actual concrete centimetre or foot, and if x denotes the numerical value of a certain line, then the complete expression for the line is x[L]" ("Encycl. Brit.," Ed. IX., Art. Dimensions). He also distinctly contemplates the introduction of these concrete quantities into equations, stating that "we may regard the symbols which occur in the equations as themselves denoting lines, masses, times, &c., or we may consider each symbol as denoting only the numerical value of the corresponding quantity, the concrete unit to which it is referred being tacitly understood;" and he then proceeds to point out the

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Yours very truly
Rayleigh

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advantages of indicating separately the concrete unit and the abstract multiplier (*loc. cit.*).

On this point, then, there is really no room for useful controversy. The symbols, [L], [M], [T], as used by Mr. Williams, do by definition represent concrete quantities wherever they occur. The point to be discussed is whether on the basis of this definition a scheme of dimensions can be elaborated for complex physical quantities by which the nature of each shall be conventionally indicated as surely as "an actual concrete centimetre or foot," or other unit of length is conventionally indicated by [L].

Even if this be granted there is still room for difference of opinion as to the dimensions of quantities with the physical nature of which we are imperfectly acquainted.—Yours, &c.,

ARTHUR W. RÜCKER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The assertion that x and y are *independent* variables, and that at the same time $ax = by$ is a contradiction in terms—that is where "the absurdity comes in."

I willingly concede to any writer the liberty to define his terms; my complaint was of a lack of definition. Anyone has a right to use L to denote a foot or a centimetre; but if he afterwards uses the symbol L^3 we are entitled to call upon him to explain what he means by the square root of a volume. If he uses the symbol LT^{-2} we may ask him to define the ratio of concretes of different kinds, and to explain what "the square of a time" may be.

An encyclopædist should not pose as a partisan, and since there are, unhappily, "two methods of interpreting the equations relating to geometry and other concrete sciences," Maxwell was bound to say so, and accordingly he states them both fairly in the words quoted by Prof. Rücker. But as to his preference he leaves no doubt. "If we adopt the first method we shall often have a difficulty in interpreting terms which make their appearance during the calculation. *We shall therefore consider all the written symbols as mere numerical quantities,** and therefore subject to all the operations of arithmetic during the process of calculation. But in the original equations and in the final equations, in which every term has to be interpreted in a physical sense, we must convert every numerical expression into a concrete quantity by multiplying it by the unit of that kind of quantity." The last sentence seems at first sight to sanction the multiplication of concretes; but it is, at least, open to the interpretation that our equations are formed from relations between concretes, and that the final result must be interpreted as a relation between concretes. That such a relation may take the form of an equation no one would deny; thus 3 feet = 1 yard is a physical equation which is perfectly intelligible; and so the expression x [L], as the complete expression for a length, where [L] is the concrete unit, is intelligible; but, in general, if such expressions are introduced into working equations "we shall have a difficulty in interpreting the terms which make their appearance." For this reason I decline to allow that the symbols [L], [M], [T] represent concrete quantities "*wherever they occur.*" The dimensional equations are obtained in one sense, interpreted in another, and half the scientific world falls a victim to the fallacy, *a dicto secundum quid ad dictum secundum alterum quid*; or, in the vulgar tongue, ringing the changes.

The truths of mathematics and mathematical physics have this peculiarity, that they command the assent of every sane man capable of understanding the processes by which they are obtained.

It follows that it is a grave objection to any such physical theory that a competent person who has examined the subject refuses his assent. Now no one can dispute either the sanity or the competence of the late Prof. James Thomson; yet in a Paper still unanswered, read before the British Association in 1878, he strongly affirmed the *change-ratio* view of the dimensional equations, and denounced, for reasons similar to those you have lately given me an opportunity of expressing, the, so-called, physical equations. "We have no right," he says, "to speak of dividing one quantity by another of a dissimilar kind, except, merely for brevity, in the case of dividing the numeric expressing the one quantity by the numeric expressing the other quantity, after we have fixed upon units of the two things."

I can understand Prof. Rücker's reluctance to accept the challenge to define his position, and his anxiety to escape the main question on the plea that there is "no room for useful controversy." But I cannot regard as useless a protest against a system which produces such a parody of scientific research as Mons. Vaschy's "Possibility of reciprocal action between an electrified body and a magnet."—Yours, &c.,

W. M. M.

* The italics are mine.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Vestry of St. Pancras invite tenders for various supplies, fixing, &c., required in connection with their extensive installation in the St. Pancras district. Further particulars are given in our advertising columns, and drawings and other documents can be seen at the offices of Prof. H. Robinson, C.E., 13, Victoria-street, S.W., where copies of the various specifications can also be seen. Tenders are to be sent to Mr. Albert E. Pycraft, at the Vestry Hall, Pancras-road, N.W., by Monday, the 22nd instant.

——— Offers are invited by the Corporation of Croydon for the transfer of the powers granted to the Council under the Croydon Corporation Electric Lighting Order, 1891. Tenders should be sent to Mr. C. M. Elborough, town clerk, by 11 a.m., on Thursday, September 15th. Further particulars will be found in our advertisement columns.

——— The Hartlepools Co-Operative Society invite tenders for lighting their new premises in Whitley-street, West Hartlepool, by electricity. Specifications (for which 2s. 6d. will be charged) may be obtained from Mr. T. Tweddell, 18, Read-street, West Hartlepool, to whom tenders must be delivered not later than Friday next, the 12th inst.

——— The Chertsey Union invite tenders for the construction of telephones, electric bells, and speaking-tube at the Union workhouse at Ottershaw, according to a specification to be seen at the office of Mr. H. E. Paine, clerk, Chertsey, to whom tenders must be sent on or before Monday next, the 8th inst.

TENDER ACCEPTED.—At a recent committee meeting of the Gas Commission it was decided to accept an offer from Messrs. J. and H. Whyte and Cooper, Britannia Engine and Boiler Works Dundee, to supply and erect for the electric lighting station (1) three steel boilers, with mountings, £1,260; (2) brick work, £190; and (3) air condensers, &c., £1,225—a total of £2,675.

APPOINTMENT VACANT.—A clerk of the works is required by the Bristol Urban Sanitary Authority to superintend the erection of the buildings, machinery, and distributing plant in connection with their electric light station. Applications must reach the Town Clerk before the 25th inst.

AWARD.—A prize medal has been awarded to Mr. John Spencer, of Wednesbury, for his exhibit of iron tubes and fittings for electric lighting purposes, &c., at the recent Crystal Palace Exhibition.

CAMBERWELL.—The Vestry of Camberwell having unanimously decided in favour of the introduction of an electric lighting plant on the site of the extensive new Public Baths and Washhouses at Camberwell Green, the Commissioners have at once put this work in hand and appointed Mr. Morgan Williams as Consulting Engineer. The contract has been secured by Messrs. B. Verity and Sons.

LEWES.—The Corporation have appointed a sub-committee to confer with a sub-committee of the County Council as to the lighting jointly by electricity of the County Hall and the municipal buildings.

LLANELLY.—At a meeting of the Local Board on Friday, it was reported that Mr. J. C. Howell had withdrawn his offer with reference to the electric lighting of the district, and decided not to accept the offer of Messrs. Andrews. The clerk was instructed to communicate with the Board of Trade upon the subject of the Provisional Order and the position of the Board thereunder, and upon receiving their reply the question will be further considered and a report made to the Board.

MITCHELSTOWN.—Mr. Abraham Sutton, of Cork, proposes to introduce the electric light in this town, and his proposal is receiving general support.

NELSON.—The Local Government Board have sanctioned the borrowing by the Corporation of £4,000, to carry out the first portion of the electric lighting scheme prepared by the gas manager.

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ATELIERS HOSTER DE SAINT-NICOLAS (LIMITED).—A petition for the compulsory winding-up of this Company was presented on the 27th ult., and will come before Mr. Justice Vaughan Williams on the 9th inst.

BANKRUPT.—Rankin Kennedy, electrical engineer, Carntyne Electric Works, Glasgow, was adjudicated a bankrupt on the 26th ult. Creditors (amongst whom are the following) are to meet in the Faculty Hall, Glasgow, on Tuesday next, the 9th inst., at 12 o'clock :—

Dorman and Smith	£9	18	4
Electrical Power Storage Company (Limited), London	4	2	0
Electrical Review, London	8	15	9
Glover (W. T.) and Co., Salford	44	5	4
India-Rubber, Gutta-Percha, and Telegraph Works Company (Limited), London	4	16	9
London Electric Wire Company (Limited), London	2	14	11
McLean (Andrew) and Co., Bridgeton	87	7	0
McLellan, P. and W. (Limited), Glasgow	10	15	9
Paterson and Cooper	10	10	6
Reid (Matthew) and Co., Glasgow	8	0	1
Richard Frères, London	3	4	8
Rome, James, Glasgow	69	6	2
Sankey (Joseph) and Sons, London	62	0	4
Thomson (W. R. M.) and Co., Glasgow	60	0	0
White, James, Glasgow	13	6	0
Yuille (Robert) and Sons, Glasgow	39	17	10

The total liabilities are set down at £714. 14*s*. 9d., and the assets, after deducting preferred claims, at £2,055. 2*s*. 5d.

COLCHESTER.—At a meeting on Wednesday the Town Council decided to take steps to obtain a Provisional Order for lighting the town by electricity.

The Crystal Palace Company and the Electrical Exhibition.

The ordinary general meeting of the shareholders of the Crystal Palace Company was held yesterday (Thursday) at the Cannon-street Hotel, under the presidency of Mr. G. T. Rait. In the course of his remarks in moving the adoption of the report, which was agreed to, the Chairman stated that the receipts from admissions during the half year ended June last had been £6,400 in excess of those of the corresponding period of 1891. This, he need hardly tell them, was due to the Electrical Exhibition ; but they must not congratulate themselves on the receipts before looking at the expenditure. The decrease in their receipts of £1,000 on account of reserved seats was no doubt due, to a certain extent, to the Electrical Exhibition attracting people from the other amusements. In the item of special *fêtes* there had been a decrease in the expenses of £3,000. They had to expend an enormous sum under this heading to attract the public, and the reason for this decrease of £3,000 was simply that the Electrical Exhibition had caused an expenditure of £7,344, which was £4,000 more, after allowing for the decrease of £3,000. This was an enormous expenditure, no doubt, on the Electrical Exhibition, and he must confess that they had been somewhat disappointed with the financial result. The large expenditure mentioned was due to the fact that in the present case the Company had had to provide the motive power to a certain extent, whereas in the case of the Exhibition of 1882, the exhibitors themselves provided this power. Fire insurance during the half-year had cost the Company £2,000, or an increase of £1,200, which was also a very heavy tax upon them in connection with the Exhibition. At a previous meeting he told them that the Directors hoped that the fire insurance people would make some reduction in the extra premium and generally in the amount for insuring the Palace. Immediately after the meeting Mr. Gardiner and himself had an interview with the fire insurance committee, when they went thoroughly into the question, the result being, he was happy to say, that the Company were met to some extent. The Committee wrote to them to the effect that if they would adopt the electric light in their theatre (this seemed a singular request in face of their having charged an extra premium for the Electrical Exhibition), and make their sprinklers automatic, they would reduce the premium from £1. 11s. 6d. per cent. to £1. 5s. per cent., and would also reduce the amount which it was arbitrary upon them to insure for from £100,000 to £80,000. He thought they could manage this, and he hoped that they would do so before long. They had the matter now practically under their consideration. It would, perhaps, be wiser for them to do this than to adopt an insurance fund of their own. He must say that he had to some extent dreaded the responsibility of having their huge property uninsured, but he thought that if they were insured for £80,000 at 25s. per cent. premium—subject to certain rebates for commissions—they would be doing a good thing, and there would be a material reduction under this head. They had not abandoned the hope of getting back the £700 or £800 extra premium from the insurance offices. They did not ask for the money back, but what they said was this : If we have no claim upon you for a serious amount during 1893, will you credit us with that amount on our premium ? That was all that the Company asked for, and he thought that this request ought to be complied with. They took every possible precaution to guard against fire ; and the fact that they had not had a single outbreak was a great proof of the advantages of electricity from a fire insurance point of view, and he was very pleased that the insurance offices had themselves suggested the adoption of the electric light in the theatre at the Palace.

COMPANIES' MEETINGS & REPORTS.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of the Anglo-American Telegraph Company (Limited) was held at Winchester House, 50, Old Broad-street, on Friday, the 29th ult., under the presidency of the Most Hon. the Marquis of Tweeddale.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the minutes of the last meeting, the latter being confirmed and signed. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said : The report contains two announcements, both of a very melancholy nature. I refer, in the first place to the death of our much esteemed and distinguished colleague, Mr. Cyrus Field. Mr. Field was a man of great ability and tenacity of purpose, and having early convinced himself of the feasibility of connecting England with America by means of a submarine telegraph cable, he applied himself with astonishing energy and perseverance to the accomplishment of this important object. After surmounting many difficulties, and after repeated disappointments, his efforts were finally crowned with success in the year 1866, since which time telegraphic communication with America has never been interrupted. Those who knew Mr. Field best, and were most closely associated with him in the great work with which his name will be always connected, are the first to bear witness to the value of his services, and to award him the honourable title of Pioneer of Atlantic Telegraphy. (Applause.) Mr. Field at all times took an active interest in the affairs of our Company, of which he was an original director. You join us, I know, in an expression of sincere regret at the loss we have sustained through his death. The second incident to which I have referred is the terrible calamity which has befallen the town of St. John's. Our connection with the Colony of Newfoundland dates from the year when the exclusive right of landing submarine telegraph cables was secured to the Company mainly through the exertions of Mr. Field. We own land lines and telegraph and telephone stations in St. John's, and have not escaped serious injury. But this is a small matter compared with the widespread ruin to the inhabitants caused by the fire ; and I am sure the shareholders of this Company will heartily endorse the action of the Directors in contributing to the relief of the sufferers. Turning now to the operations of the half-year under review, it is a source of satisfaction to be able to point to a steady, if slight improvement in our traffic receipts, amounting for our share to £10,000. Unluckily, our expenses have increased as well, so that comparatively a small portion of the increase is available for dividend. The expenses of the s.s. "Minia" are higher by £3,000, mainly in consequence of repairs required by the Board of Trade. Working expenses are about £2,000 in excess of the preceding half-year, the increase being almost exclusively due to the expenditure on new stations rendered necessary by the keen competition for business. Then we are minus the £1,500 which the s.s. "Minia" earned for us in 1891. The net result is a sum of only £3,500 over and above the corresponding half-year of 1891, applicable to dividend, or just sufficient to pay an additional 1s. per cent. on the half-year. Having regard to the extraordinary stagnation which has prevailed in commercial circles ever since the Baring failure, as well as to the active competition for Atlantic telegraph business, to which I have just referred, the result cannot be regarded as altogether disappointing. Speaking for myself, I cannot but believe that the day will come when the rival Companies will see the advantage of making some arrangement by which the enormous amount now unprofitably spent—I might say squandered—in competition would be saved and the public in no way prejudiced, but, on the contrary, greatly benefited. Certain it is that until something of the kind comes to pass, we cannot hope for any diminution in our working expenses. The state of the renewal fund is naturally an object of great interest to all classes of shareholders, and it will no doubt be a great disappointment to find that, owing to the large expense attending the repairs of cables, more particularly the Brest Cable, the time has not yet arrived when we could consider the propriety of applying the interest to dividend. It is this which renders another break in the same cable, mentioned in the report, all the more tantalising, for its repair must entail a considerable expenditure. The repairing ship is on the spot, and if the weather continues fine we may hear any day or even hour of the repair having been effected. With regard to the lawsuit I have nothing to add to what is stated in the report. I met our French solicitor in Paris a short time ago, and learned that there was little prospect of the appeal being reached before the spring of next year. Our duty is clear, and it is to maintain the high state of efficiency for which our service is distinguished, and we trust to that to receive a still larger share in the public business. In conclusion I have only to express the opinion that, although the increase in our expenses is a regrettable feature, yet being more than balanced by increased traffic receipts—an increase which has occurred in a time of unexampled commercial depression—we are entitled to look forward with confidence to a more prosperous state of things in the coming half-year. With these remarks I beg to move—

"*That the report of the Directors and the accompanying statement of accounts to the 30th June, 1892, submitted to this meeting be and the same are hereby received and adopted.*"

The DEPUTY-CHAIRMAN (Mr. Francis A. Bevan) seconded the motion.

Mr. GRIFFITH said the shareholders would no doubt all join in the expression of regret at the death of Mr. Field. They could only hope that his mantle had fallen upon persons able to carry on the great work which he initiated, and he thought that they had reason to say that that hope

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was to a great extent already justified. Notwithstanding the luminous statement given by the Chairman, there were many questions that struck him as worthy of consideration, and one was that they might improve the balance-sheet if they could get rid of the very large item, "unclaimed dividends." As they at present stood, perhaps they could not do so; but it seemed to him that the time was rapidly coming when they might consider whether that amount should not be distributed among the deferred shareholders, who had for so long a period received no dividend at all. Of course in these transactions they must act according to strict rule, and that he hoped they would always do. What he desired was that the Directors would accelerate the time when the deferred shareholders would get some relief.

Mr. E. H. BOURNE suggested whether it would not be wiser to let the Brest and St. Pierre cables lie and rot at the bottom of the sea, seeing that it cost £20,000 to £25,000 a year to repair—a sum equal to one per cent. dividend.

The SECRETARY: £25,000 would represent only ⅝ per cent.

Mr. BOURNE said he knew that all the repairs which had been done to the cable were of no practical use. As soon as it was repaired it was broken again—in a month or so; and under the circumstances would it not be better to abandon it altogether?

Mr. HANCOCK said that the position of the deferred shareholders had been referred to at these meetings from time to time. There was a deferred capital of over £2,900,000 upon which nothing had been paid for a long time, which was not a creditable thing to the Directors of the Company. He thought that the time had come when the Board ought to turn their attention to such a remodelling of the state of affairs by which the deferred shareholders would receive something for their money. He thought that it was their duty before the next meeting to give serious consideration to the matter and propose a scheme which would be more just to that class of shareholders.

Mr. LOTT noticed that there was generally a good deal of grumbling at these meetings from the deferred shareholders. There were two methods by which they might help themselves; let them sell deferred and buy preferred shares. He had done so himself. The other was to help the Company to prosper by all the means in their power. He was interested in several companies which traded with America, and he had always endeavoured to induce the people who were in the habit of sending cablegrams across the Atlantic to do so through the Anglo-American Company. He really could not see that there was any ground for grumbling at the management of the Company, for he thought it was a most eloquent testimony to their ability.

The CHAIRMAN said that he was afraid he could not help Mr. Griffith in the matter of the unclaimed dividends. He did not understand whether that gentleman suggested that they should make use of that money now.

Mr. GRIFFITH was understood to suggest that after a reasonable time in the future the money should be forfeited for the benefit of the deferred shareholders.

Mr. CHARLES BURT: The Stock Exchange will not allow a quotation of the shares of a company which has that clause in its articles.

The CHAIRMAN said that the Brest Cable was a most disappointing one, owing to the cost of the repeated faults in it. If they could place it in some safe part of the ocean they might probably be relieved from these accidents, but this could not be done without a large expenditure. But they could not get on without it. They could not do without their communication with France, for in that case they would lose the traffic. Mr. Hancock had suggested the remodelling of their affairs with the view of giving the deferred stockholders a dividend. But he (the Chairman) honestly did not think that their affairs could be so remodelled. The dividends were declared on the ordinary stock, and the deferred could only get something after the preferred had received its full dividend. As to the reserve fund, that was another matter; if the whole of the interest of the reserve fund had been placed to dividend account it would not have benefited the deferred shareholders at all; and they did not propose to take any of the reserve fund until it reached £1,000,000. He hoped that the favourable remarks made by Mr. Lott would be shared by the other stockholders.

Mr. GRIFFITH proposed and Mr. NEWTON seconded a vote of thanks to the Chairman, which was carried unanimously.

The proceedings then terminated.

Direct United States Cable Company (Limited).

The thirtieth ordinary general meeting of this Company was held on the 29th ult., at Winchester House, under the presidency of Sir John Pender, K.C.M.G., M.P. (Chairman of the Company).

The Secretary (Mr. T. Finnis) read the notice convening the meeting, and the minutes of the last half-yearly meeting, which were confirmed.

The CHAIRMAN then said: Gentlemen, I presume you will take the report as read. Before moving its adoption I shall, as usual, go over some of the figures which refer to the last six months' operations, so that you may carry away with you a perfect idea of the working of this business. The revenue for the half-year to June 30th last., after deducting outpayments, amounted to £39,015, and the working and other expenses, including income-tax and depreciation of spare cable, but exclusive of cost of repairs, to £19,019, leaving a balance of £19,996 as the net profit of the half-year, making, with £4,983 brought forward from the previous half-year, a total of £24,979, which has been appropriated as follows:—Interim dividend of 3s. 6d. per share for the quarter to March 31st, £10,624; proposed final dividend of 3s. 6d. per share for the quarter to June 30th, £10,624; balance proposed to be carried forward, £3,731; total, £24,979. The revenue, as compared with that in the corresponding period of last year shows an increase of £1,662. This is not a large improvement, but business generally has not been brisk during the period under review. The expenses in London show a small reduction in salaries and a small increase in printing and stationery, the other items being practically the same as before. These disbursements are, on the whole, £24 less than in the corresponding period. The expenses at stations also show a small reduction in salaries, and a considerable reduction in maintenance. On the other hand, rent and taxes are somewhat higher. The stations expenses on the whole have absorbed about £140 more than in the corresponding period. The further general expenses show a reduction in Directors' remuneration and a small increase in law charges; but taking the normal working expenses as a whole, it will be seen that they are only £49 in excess of those in the corresponding period, viz.:—£17,604, against £17,555. The remaining items charged against revenue are income tax, depreciation of spare cable, and freight of cable. These are items which are scarcely under control, and it is to these items alone that the increase shown in the expenditure, as a whole, is due. Turning now to the reserve fund account, it will be seen on the credit side that the interest on the investments amounted to £4,421, while on the other side the amount charged for repairs of cables is £9,385, leaving the balance of the reserve account standing at £254,716. In the balance sheet a sum of £9,000 is standing on the "acquisition of patent rights account," and represents the balance of amount paid on that account in lieu of continuing an annual payment of royalty, and covers also any and every improvement made since the date of the Company's original duplex agreement. It is proposed to write off this balance against the revenue account at the rate of £2,000 per annum, which is exactly the sum heretofore charged to that account for the duplex royalty. It will be in your recollection that this duplex system, which is probably one of the most remarkable inventions since submarine telegraphy has been established, has practically doubled the working power of our cables. I have always considered that but for that system we should have probably required more cables; but with the existing cables together with the duplex system, we have a great deal more carrying power than the present traffic requires. The investments remain unaltered since the last meeting, and their present market value continues much higher than the figure of "cost" at which they stand in the accounts. This completes a brief summary of the accounts for the half-year; but it must be borne in mind that the June six months is always the lean period, and no fair idea of the working can be obtained without looking at the twelve months as a whole, and when so considered it will be seen that the Company, after paying all expenses, including somewhat heavier repairs than usual, together with the usual dividend of 3½ per cent., has fully maintained its position during the past financial year. Now, gentlemen, I have given you what you would call the hard facts connected with the working of our system. I should only have been too pleased to have told you that our dividend-earning power is increasing, but unfortunately the amount of cable power in the Atlantic, allowing for the duplex system, is equal to something like twenty cables. I remember in the early days of submarine telegraphy the difficulties we had to get sufficient money to lay one cable. But the first cable was laid after great difficulties, and it was duplicated. Then America began to take heart and laid cables, with the result that we are labouring now under what I may call a surfeit of cables in the Atlantic. I hope that those who look to this field for a harvest in the future will take to heart the lesson taught by the fact that at the present time we have sown a great deal more than we are yet reaping a return from. Having said so much upon the working of the system, there are two or three other things I should like to refer to. In the first place since I met you six months ago we have had some great changes. Old friends have passed away—friends who were associated with submarine telegraphy from its inception. Foremost amongst these is Cyrus Field, who was particularly active and prominent in the earlier history of submarine telegraphy, especially Atlantic telegraphy. I recollect shaking him by the hand when he first came over to this country, and I was one of the first men who joined him in his Atlantic cable enterprise. Cyrus Field was a man of indomitable energy; but somehow or other a series of difficulties occurred in those earlier days, and for a few years Field's activity in America did not result in inducing the public to subscribe the necessary money to go forward with. The movement, however, was taken up on this side, and owing to the courage and perseverance characteristic of the people of this country we were enabled to go on and obtain success. Knowing Cyrus Field as I did I say we are deeply indebted to him for the active and energetic part he took in those earlier days; and when the history of submarine telegraphy is recorded his position will not be a mean one in that record. And then, gentlemen, since I last addressed you, we have lost two Directors. Mr. Ford, as you know, had to do with this Company since it became what I call a rescued Company—a Company that had for years existed but which paid no dividends—and had continued to be associated with it from the time when we entered upon a new departure, and paid fair dividends. The other Director whom we have lost is Admiral Mayne, M.P., who was also connected with us from the beginning. They have now passed away. Both were valuable and experienced men, and I have here, as one of their colleagues, to express deep regret at losing them. But such is life. These changes will occur, and the result is that other men take their place and the world goes on very much as before. There is another question, and that is the French suit. We have not mentioned it in the report because we are so tired of seeing it there from time to time without being able to give any definite information, and we thought it better to leave it out. All I can say is, if you ever quarrel with a Frenchman, never get into a lawsuit with him. I frankly tell you that I do not see the end of the case any more than I did at the commencement. I do not suppose it is a very expensive business, because surely even lawyers cannot run up bills without working, but we have a suit which seems to me to be interminable. We think we are in the right. I might mention that this suit is managed from this side by our colleagues, the Anglo-American Company, but I must leave it to wiser heads than mine to

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say when it will be decided. At all events we shall keep a watch upon it, and I shall be immensely pleased if it terminate in my day. We have had, gentlemen, more than the ordinary amount of expenditure upon repairs during the past six months, but we have made it a rule that as soon as a break occurs to take steps to repair it. That course we have always pursued, and, unfortunately, the necessity arises a little oftener than is pleasant for us, and satisfactory for the exchequer. And then we cannot stand still. Our people have been living in wooden huts at Ballinskelligs, and we now find it is necessary to spend a little money there. The expenditure will be made judiciously, and it will not affect your dividends. At any rate, our people will be housed more comfortably, which is a matter that must always receive proper consideration. We are trying to maintain our fair share of the working in the pool, and we are spending a little more money on canvassing, and so far as we have gone the result of the canvass has been to pay us fairly well for the sum of money expended upon it. Now, gentlemen, as I have often said here, submarine telegraphy is a great barometer of trade. What is going on here in England is known at once all over the world, and what is going on all over the world is at once known in England. And trade is affected for good or bad according to the state of the political horizon. I hope there is good trade still in store for us, but I also say that until we are settled down upon a firm sound basis, trade will not grow. Trade rests upon confidence, and when confidence is assured—as I hope it will be in this great and grand old country—you may depend that after a cycle of depression we shall have a cycle of prosperity, and in that prosperity the submarine telegraph system will always largely share. I beg now to move :—

"*That the report of the Directors, dated July 15th, 1892, together with the statement of accounts to June 30th, 1892, annexed thereto, be and the same are hereby received and adopted; and that a final dividend be now declared of 3s. 6d. per share, free of income tax, making, with the interim dividends already paid, a total dividend of 3½ per cent. for the year ended June 30th, 1892.*"

Mr. E. M. UNDERDOWN, Q.C., seconded the motion.

Mr. JOHN NEWTON regretted, as he had wanted to attend the meeting of the Anglo-American Company, that the meetings of the two Companies had been convened, for the first time, on the same day and at the same hour. Many other shareholders besides himself would have liked to have been present at both meetings.

The CHAIRMAN said he believed he was personally to blame. It was not an accident, but it arose from circumstances which were difficult to control. They had always tried to have a week between the meetings of the two Companies, but it so happened that the election business came up this time, and he could not be in two places at once. At one time they had thought it might be possible to have held the meeting last Friday, but a good deal of work crowded into that day, and they therefore resolved to hold it to-day.

Mr. NEWTON said that the difficulty would have been overcome if the Direct Meeting had been called for one o'clock instead of two. Everything else was, however, satisfactory, including the dividend. He felt sure that the death of a man like Mr. Ford was a cause of grief to all the proprietors. The death of Mr. Field was a great loss to the enterprise of telegraphy; and there was one feature in connection with his death which he (the speaker) could not help being struck with. He referred to the acknowledgment in the Press of Mr. Field's services, and the very little acknowledgment, if any, which was paid to those who provided to a large extent the funds for the grandest work ever accomplished.

Mr. MARMONT asked if there was any idea of issuing the 4,000 unissued shares, and if so, whether they would be issued *pro rata* to the shareholders.

The CHAIRMAN replied that the fact was that they did not want the money, and they did not wish to increase the capital. He therefore thought that it would be better to keep the shares where they were. They could not issue them at £20 a share, the par value, and they were not allowed to issue them under that.

The resolution was then unanimously adopted.

On the motion of the Chairman, seconded by Mr. James Pender, Mr. C. J. Günther was re-elected to his seat at the Board, as was also Admiral of the Fleet the Hon. Sir Henry Keppel, G.C.B., D.C.L., on the motion of the Chairman, seconded by Mr. Underdown.

Messrs. John G. Griffiths, F.C.A., and Mr. John Sawyer, F.C.A., were afterwards re-elected auditors for the ensuing year.

Mr. UNDERDOWN said it was unusual for a vote of thanks to the Chairman to come from the Directors' side of the table, but he thought the meeting would join with him in congratulating Sir John Pender upon his election to the House of Commons, and he had no doubt that the House would derive great advantage from the presence of their Chairman. He was fully convinced that Sir John Pender was one of the men who ought to be in the House, and who ought to remain there.

The motion was adopted.

The CHAIRMAN : I am very much obliged to Mr. Underdown for the handsome way in which he has referred to me. I have been associated with this Company for a very long period. I believe that the submarine system, in which we all take such an interest, has done an immense deal during the last twenty-five years to promote not only the commercial growth of the country—I may say of the world—but I think it has knit together the world in a way that makes us much more powerful than we were before submarine telegraphy was established. Some of you may think that in going into political life again at my age, I am doing a foolish thing, particularly after I have had all the comforts and enjoyments of six years out of it. But there are times in the history of the country when the oldest and the youngest men ought to feel that they have a duty to perform. I look upon the present period as one marking a crisis in this country, and I feel that with the life I have led heretofore, and with the little life I may have still left in me, I should not like to be out of the fray in maintaining the integrity of the country of which we are all so proud, and which many of us have taken an active part in building up. There is nothing political, I hope, in this ; it is simply patriotic, and nothing more nor less.

The proceedings then terminated.

Crompton and Co. (Limited).

The fourth annual general meeting of the members of Crompton and Co, (Limited) was held at the City Terminus Hotel, Cannon-street, on Friday. July 29th, to receive and consider the report of the Directors, and the audited statement of accounts and balance sheet for the year ending March 31st, 1892, to elect a Director and auditors, and to transact the ordinary general business of the Company. Mr. Rookes Evelyn Bell Crompton (one of the Managing Directors) presided.

Mr. Francis R Reeves (the Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN : Gentlemen,—I have now to move that the Directors' report and statement of accounts for the year ending March 29, 1892, be taken as read and received, and adopted. I am happy to say that the remarks that I have to add to-day on the subject of the report will be brief. Happy is that Company which has got nothing to explain away ; and that is our case. We have carried on the year's business in a manner which has been substantially satisfactory. The reason that our profits have not been still larger is due to no want of economy in our working ; for I may say that by watching and diligence we are now working at a greater economy than we have ever reached before. But it is simply due to the fact that there has been greater competition, and consequently prices have been reduced, and the margin available for profit upon the various orders has been very much smaller than formerly. Our electrical business, as you know, is a very progressive one, it demands great sacrifices on the part of manufacturers, and, which is a matter of very great importance, the sums are practically taken away from the profits of the year—the sums which have been devoted to improvements, as it is quite impossible to sub-divide up all these items so as to put them to a suspense account. The nature of the work which has been carried on during the year has been, some of it, of a special character, and we have taken our share of the contracts which have been going. We have done a certain amount of these large contracts, and our name has been published in connection with such as the Notting-hill, the Westminster, and other London contracts. We have also completed our contract for the lighting of the City of Pretoria in the South African Republic. At the present moment we are in negotiation for some very large contracts of a most important kind, but which for obvious reasons I do not specify more particularly here. Perhaps, however, I might say that your Directors believe that our prospects of profit in connection with all of these contracts—if they are obtained by us—will be at least as good as the results have been from those that we have undertaken in the past. And as our economy in working has been exceedingly progressive, I hope if we do obtain these contracts that we shall be able to show you at least as good profit as we have made in the past—if not a greater one. The experiments, or rather the money that we have spent in experiments, in connection with electrical hauling, has been so far completely successful, and we are receiving orders for electrical hauling plant to an extent that already occupies a very considerable proportion of our order sheet. The next point that I must notice is that we have no trouble whatever with our workmen. Our workmen, we find, are very steady going, and there is a state of good feeling grown up between our workmen and ourselves which is very gratifying, and which still continues. We have been trying an experiment during the past year of a very interesting nature—it has been this, that we have issued a certain number of our debentures to our workmen, under such terms that although the workmen have the perfect security which our debentures afford, they are allowed to participate in the profits of the undertaking by having the interest that they receive on their debentures raised to a rate of interest equal to that which is paid on the ordinary shares. That, gentlemen, virtually makes our workmen partners with ourselves in the undertaking, and I hope that the plan will have a very good effect in the future. The scheme has been at work for such a very short time that it is quite impossible to be able to tell at present as to what its effect has been. But the fact that those who have taken these debentures, men such as our foremen, chief managing clerks, and other men who can materially assist us in making our profits, is a fact that, taken by itself, is a very encouraging sign. I have another word to say. You are aware that we have not for some time past had a regular chairman; but I am very glad to tell you that one of our Directors, Viscount Emlyn, whom we have had for some time upon our Board, now finds his engagements such that in the course of the next few months he hopes to be able to take upon himself the position of permanent chairmanship of this Company, and I need hardly say that this will be a very great relief to me personally, my own work as Managing Director being sufficiently engrossing and taking up so much of my time that it is quite impossible that I could do justice to the two offices; and I think it will be a very great advantage to us to have such a well-known and well-tried business expert as Viscount Emlyn to occupy the position of Chairman of this Company. I do not know that I have much more to tell you. You may, perhaps, remember that I stated to you last year that we propose to issue the balance of the preference shares, and that it would be a great advantage to the existing shareholders that that balance should be so issued, as it would enable us to obtain a Stock Exchange quotation on these new shares, and the same remark applies to the small balance of debentures that yet remain unissued. So soon as those two balances are issued, we

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shall be in a position to apply to the Stock Exchange for a quotation for the new issue of the preference shares and for our debentures also; and I have no doubt that you will consider that will be an advantage I feel certain that you will agree with me that taking into consideration the reduction of prices, due to competition, and the fact that trade, as a whole, has been rather on the decline, during the latter half of this year, that the profits earned are very satisfactory, and that they really require no further comment on my part. These profits have been earned by keeping down expenses and careful management, and I think that we have very greatly to thank our administrative staff for the excellent results obtained. I conclude by moving—

"That the Directors' report and statement of accounts for the year ended March 31st, 1892, be received and adopted."

Viscount EMLYN seconded the motion.

The CHAIRMAN invited discussion.

Mr. T. R. TUFNELL: Well, Mr. Chairman, I need hardly say that I do not rise to propose an amendment to the report. I agree with you, Mr. Chairman, in looking upon it as one of a most satisfactory character, but there is one suggestion I should like to make, and it is this: Looking at the steady progress which the Company appears to be making, and the profitable business which the Company appears to be doing, and the admirable way in which our business appears to be conducted in every respect, and also to the increase which has lately taken place in the number of our Directors, and certainly considering that which you have just mentioned, the addition to your numbers of Viscount Emlyn—who I shall be only too pleased to see the Chairman of the Company—under these circumstances I should like to suggest that some sum beyond £1,000—say, £1,300—should be paid to the Directors annually as their remuneration—that is, that they should get an addition of £300 per annum—if any gentleman on this side of the table will second my proposal.

Mr. HANCOCK: I shall be very pleased to second that.

Mr. TUFNELL: Perhaps, Mr. Chairman, you could hardly put that resolution; it would come from the shareholders.

The CHAIRMAN: Yes, sir, from the shareholders; but I think, perhaps, it would be more convenient if you would permit the resolution which you have just raised to stand over for little while, and that I should now, subject, of course, to any questions any shareholder may desire to ask thereon, put to the meeting the motion which has been moved by myself, and seconded by Viscount Emlyn, that the Directors' report and statement of accounts be received and adopted. Those who are in favour, on the contrary—that is carried. I have now to move—

"That a dividend of 3s. 6d. per share, being at the rate of 7 per cent. per annum for the half-year ending March 31st last, be declared and paid upon the preference shares of the Company."

Mr. B. GIBSON: I have much pleasure in seconding that.

The motion was carried.

The CHAIRMAN: I have now to move—

"That a dividend of 4s. 6d. per share, making with the interim dividend 7 per cent. per annum, be declared and paid upon the ordinary shares of the Company."

Mr. H. H. J. W. DRUMMOND seconded the motion.

The motion was carried.

The CHAIRMAN: I have now to move—

"That Mr. Carlton Fowell Tufnell be, and he is hereby, re-elected a Director of this Company."

Mr. Tufnell has been a Director of this Company from the first, and is one of the hardest of our workers. It is not necessary for me to say anything further beyond that I sincerely trust that he may be re-elected a Director of this Company.

Mr. PAYNE: Would you like it seconded from this side of the table?

The CHAIRMAN: If you please.

Mr. PAYNE: I shall be pleased to second it.

The motion was carried.

The CHAIRMAN: I shall be very glad if some shareholder will move the re-election of the auditors.

Mr. PAYNE: Mr. Chairman, I had the privilege of proposing that resolution last year, and I have much pleasure in doing so again this year. The accounts appear to be thoroughly well kept, and it seems to me that Messrs. J. H. Duncan and Co. do their work as it ought to be done, therefore I have no hesitation in placing their names before the meeting—that they be re-elected as auditors for the ensuing year, at the usual remuneration of 25 guineas.

Mr. T. R. TUFNELL seconded the motion, which was carried.

The CHAIRMAN then intimated that they would be prepared to receive Mr. Tufnell's resolution.

Mr. T. R. TUFNELL: Mr. Chairman, as I am in order now, I shall be glad to move—

"That looking at the steady progress which the Company is making, and the increase which has taken place upon the Board of Directors, the Directors' remuneration be increased by the sum of £300 per annum."

Mr. HANCOCK seconded the motion.

The resolution was put and unanimously carried.

The CHAIRMAN: Gentlemen,—We have to thank you for your very kind vote, which I assure you will be greatly appreciated by the Directors. I have very little to add to what I have already said, that the Directors of this Board have had no easy task. Such a business as ours is one that entails a considerable amount of anxiety and of trouble upon the management, and I can assure you that we, the Managing Directors, have done all in our power to avoid any difficulty, and I do not disguise it that it is greatly due to the tact and management of the Board that we have succeeded, and I think, gentlemen, that you may felicitate yourselves upon having such a good Board. Unless any shareholder has any further questions to ask upon any subject, that concludes the business of the day.

Mr. T. R. TUFNELL: I do not know whether we may take it that the lesser is included in the greater; but, perhaps, you will permit me to propose a resolution, that the thanks—the cordial thanks—of this meeting be accorded to yourself as Chairman and to your co Directors, and I should like to include the name of our valuable Secretary, Mr. F. R. Reeves, and also our thanks to the staff.

Colonel WOOD seconded the motion, which was carried by acclamation.

The CHAIRMAN: We are much obliged to you, gentlemen.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

BROADBOTTOM GAS COMPANY (LIMITED).—This Company was registered on July 28, 1892, with a capital of £1,400, in £1 shares, to acquire the retort-house, gas-holder, and other buildings at Broadbottom, in the county of Cheshire, and reserves the right to light the village of Broadbottom and the adjoining districts with electricity.

DAY'S GAS ENGINE COMPANY (LIMITED).—This Company was registered on July 29th, with a capital of £60,000, in £5 shares. The objects are to enter into and carry into effect an agreement, dated July 11, 1892 (the parties to which are not mentioned), for the acquisition of the English and foreign patents already or hereafter to be granted to Mr. Joseph Day, for improvements in gas-engines; to manufacture gas-engines under the said patents; to grant licences for the manufacture of gas-engines under the said patents; and to carry on the business of mechanical and general engineers, iron and brass founders, smiths, machinists, &c.

DOWIE AND HANDYSIDE (LIMITED).—This Company was registered on July 26th, with a capital of £4,000, in £1 shares, to acquire, and take over as a going concern the business of mechanical and electrical engineers, iron and brass founders, boiler makers, wire drawers, iron and steel cable makers, millwrights, metal workers, &c., carried on by Cecil M. Dowie and Charles B. Handyside, at 418, Oldham-road, Newton Heath, Manchester, under the style of "Dowie, Handyside and Co."

ONCKEN PATENT STAVELESS BARREL COMPANY (LIMITED).—This Company was registered on July 30th, with a capital, of £150,000, divided into 50,000 ordinary and 25,000 deferred shares of £2 each. The objects include the carrying on of the business of treating wood and other materials and substances by electricity and chemicals.

SLAG REDUCTION COMPANY (LIMITED).—This Company was registered on July 29th, with a capital of £50,000, in £10 shares, to enter into and carry into effect an agreement for the acquisition by the Company of certain patent and other rights for the use of attrition mills and magnetic separators, together with certain plant, machinery and premises, and to carry on the business of manufacturers of and dealers in machinery for crushing, grinding or separating materials or substances, smelters, engineers, iron founders, chemical manufacturers, &c.

SOCIETE D'ELECTRICITE DE LA MEDITERRANEE, SOUCHIER ET CIE.—A Company has been formed with the above title, with a capital of 250,000fr., to exploit the electrical industry in Marseilles and neighbourhood.

HOBART TRAMWAY COMPANY (LIMITED).—The statutory return of this Company made up to July 14th, was filed on the 26th. At the time of making up 45,067 of the total capital of £105,000, in £1 shares, had been taken up, of which 20,000 had been issued as fully paid. On the remaining 25,067 shares the full amount had been called, resulting in the payment of £25,061. 15s., and leaving five guineas in arrears. The total amount of shares for which share warrants, comprising five shares each, are outstanding, is £1,250.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 31st were £735, as against £692 for the corresponding period of last year, being an increase of £43. The total receipts for half-year amount to £3,784, against £3,477 in the corresponding period of 1891, being an increase of £307.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—At a meeting of the Directors of this Company, on Wednesday, audited accounts for the half-year to June 30th were submitted, and it was resolved, after providing for the dividend on the preference shares, to recommend a distribution on the ordinary at the rate of 8 per cent. per annum, free of income-tax. The estimated traffic receipts for the month of July were £3,100, as compared with £3,186 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the month of July amounted to £1,684, as compared with £1,667 in the corresponding period of last year, an increase of £17.

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EASTERN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the month of July amounted to £49,117, against £52,303 in the corresponding period of 1891.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of July amounted to £41,714, and to £41,219 in the corresponding period of last year, an increase of £495.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).—An interim dividend has been declared on this Company's ordinary shares at the rate of 4 per cent. per annum for the half-year ended June 30, 1892.

NEW TELEPHONE COMPANY (LIMITED).—We learn that the subscription for shares in this Company, the prospectus of which appeared in our last issue, was largely over-subscribed, although the list was only open for a few hours. Over two millions is the figure given as the amount of applied for.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 29, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,028.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the fortnight ended July 31, 1892, show a decrease of £57 as compared with the corresponding period of 1891.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 27.	Price Wednesday, Aug. 3.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 3. Highest.	Lowest.
			TELEGRAPHS			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American ..... xd	48½ 49½	47½ 48½	5 8 2	Jan., Apr., July, Oct.	..	..
£2,876,140	Stock	25/0	Do. Preferred ..... xd	88½ 89½	87½ 88½	6 10 0	" "	..	..
£2,876,140	Stock	5/0	Do. Deferred	11 11½	11 11½	..	" "	11 1/16	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 103	99 103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½ 10¾	10½ 10¾	6 19 3	Mar., June, Oct., Dec.	10¾	10½
£68,200	£100	5%	Do. 5 per Cent. Bonds ..... xd	101 104	99 102	4 18 0	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	160 165	160 165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	11¾	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3¾	3½ 3¾	4 16 9	April and October ..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½ 11¾	11½ 11¾	5 19 2	Jan., Apr., July, Oct.	11¾	11½
400,000	10	5/6	Eastern ..... xd	15 15½	14¾ 15	4 6 8	" "	15	14¾
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	15½ 16	15½ 15¾	3 16 2	" "	15¾	15⅝
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	..	..
£300,000	100	5%	Do. 5 per Cent. Debentures 1899 ..... xd	108 111	106 109	4 11 9	February & August	108½	..
250,000	10	2/6	Eastern Extension	15 15½	15 15½	4 12 7	Jan., Apr., July, Oct.	15½	15
£330,000	Stock	4%	Do. 4 per Cent. Debenture Stock ..... xd	108 111	107 110	3 12 9	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102 105	102 103	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 ..	101 104	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.) xd	102 105	101 104	3 16 11	February & August	..	..
180,227	10	3 9	Globe Telegraph and Trust ..... xd	10⅛ 10⅜	10 10½	4 15 1	Jan., Apr., July, Oct.	10½	10
180,042	10	6%	Do. 6 per Cent. Preference ..... xd	15½ 15⅝	15 15½	3 19 8	" "	15⅝	15
150,000	10	5 0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	18⅓	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	..	..
17,000	25	1⅜	Indo-European	40 42	41 43	5 16 3	May and November	42	41½
28,848	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October ..	..	..
2,381	£100 Cert.	£1½	Submarine Cables Trust 6%..37/6 Bal. Ap. Coup. xd	115 120	115 120	5 0 0	" "	..	..
15,609	10	5/0	West African Telegraph ..... xd	6 8	6 8	5 0 0	January and July ..	7½	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	3½ 4½	3 4	..	January and July ..	3⅜	..
£150,000	100	8%	Do. Debentures 8% 1902	101 105	102 106	7 10 11	June and December	104	103½
88,321	10	6d.	West India and Panama	1½ 1⅝	1½ 1⅝	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 9¾	9½ 9¾	6 3 1	May and November	9½	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
64,242	15	6/0	Western and Brazilian	8¾ 9⅛	8¾ 9⅛	6 9 7	" "	9	8⅞
33,129	7½	1/6	Do 5 per Cent. Cumulative Preferred	6 6¾	6 6¾	5 15 7	" "	6¾	6½
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾ 3¼	2¾ 3¼	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910 .. xd	105 108	102 105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910 xd	105 108	102 106	5 14 3	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 123	118 122	5 14 9	May and November	..	..
£175,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
224,550	14/0	1½d.	Consolidated Telephone Const. & Maintenance ..	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
120,000	£1	4½d.	Oriental (11s. paid)	⅛ ¼	⅛ ¼	7 18 2	Yearly	..	..
438,984	5	3/6	National	5 5½	4½ 4¾	6 3 1	June and December	4 1/16	4 1/32
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref. ..... xd	13⅞ 14½	13½ 14	4 5 9	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. ..... xd	13¼ 13¾	13 13½	4 8 11	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109 111	109 111	4 1 1	January and July ..	110¾	109¾
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	—	—	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	9⅝ 10½	9½ 10½	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	—	—	—
8,332	£5	..	House to House Electric	..	..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	..	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.	..	..	January and July ..	..	..
30,000	£5	4¼%	Liverpool Electric Supply (£3 10s paid)	3 7/16 3 9/16	3 7/16 3 9/16	..	March	..	..
10,000	£5	4¼%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	..	March	—	..
111,000	5	..	London Electric Supply	..	¾ 1⅛	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾ 7½	6¾ 7½	..	—	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid).....	4 5	4 5	—	—	..	..
13,680	£5	2/6	St. James' and Pall Mall ..... xd	7½ 8	7½ 7¾	—	—	7⅜	7 1/16
7,900	£5	7%	Do. 7% Preference ..... xd	7¾ 8¼	7¾ 8¼	..	—	8	7 13/16
42,858	5	..	Westminster Electric Supply (fully paid)	5¾ 6¼	5¾ 6¼	..	..	6 1/16	5⅞
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/9	Brush Electrical Engineering	2⅞ 3⅛	2⅞ 3⅛	..	..	2 15/16	..
69,996	3	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2 3/16	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5½ 6	5 16 8	January and July ..	..	..
12,139	5	17%	Edison and Swan United	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	4⅜ 5¼	4⅜ 5¼	..	—	4⅜	..
70,000	3	10/0	Elmore's Patent Copper Depositing	2⅛ 2⅜	2⅛ 2⅜	—	—	2⅜	2⅛
20,000	5	..	Fowler-Waring Cables (fully paid).....	3 3	3 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works ..... xd	20½ 21½	20½ 21½	5 16 3	February & August	21½	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1/16 1/8	1/16 1/8	..	..	..	..
78,949	5	2/9⅓	Swan United (£3. 10s. paid)	3 3¼	3 3¼	11 0 0	May and November	3⅛	..
87,350	12	12/0	Telegraph Construction and Maintenance .... xd	44 46	44 46	5 4 6	March and July.....	..	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)..	..	..	..	—	..	..
—	£5	8%	Do. Preference (fully paid).....	—	—	..	—	—	—
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	—	—	—	—	..	..
50,000	£10	..	City and South London Railway	2½ 3½	2½ 3½	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

The Edinburgh meeting of the British Association has been attended by a smaller number of members than was expected, though of course the attendance was better than last year. Every effort was made to encourage local interest by giving prominence to local notables. A good many men well known at scientific societies, but rarely seen at meetings of the British Association, had been attracted by the promise of an International Conference on Electrical Standards. In Section A, however, English spoken with a German accent was as noticeable as the more musical Scotch. The German contingent, led as it should be by Prof. von Helmholtz, added largely to the value of the proceedings; but, while most of their Papers and discussions were of great worth, they rather congested the programme, and thus upset the order and despatch of the work.

Out of 64 Papers read before Section A, there were 39 connected with, and for the most part entirely concerned with electrical science, and 25 were non-electrical. In Section G, out of 32 Papers, 10 were electrical and 22 were non-electrical.

The value of the extremely hurried work of Section A, as far as the Sectional Meetings are concerned, cannot be properly judged at present; and our readers, who will have an opportunity of seeing most of the Electrical Papers, or abstracts of them, in these columns, will be really in a better position to appreciate them than if they had heard them read. As to the Electrical Papers read in Section G, several, such as those of Mr. Preece, were short notes. Mr. Kapp exhibited an interesting set of curves showing the performance of alternate-current motors.

The International Discussion on Electrical Standards was a great disappointment to many of the members, to all, in fact, except the members of the committee, for it was carried on behind closed doors, and only a report was "presented;" that is to say, it was given in a short verbal summary by Mr. Glazebrook, none of the arguments or reasons which led to its adoption being disclosed. We hope, however, to be able to furnish our readers, many of whom take a keen interest in the matter, with an account, unofficial, but on the best authority, of the proceedings of this committee.

Another disappointment was the expected discussion on a National Physical Laboratory. A large audience of about 115 members—that is, about four times as many as were usually to be found at the meetings—were interested in hearing Dr. Lodge's scheme; Prof. von Helmholtz's account of the Reichanstalt, the Government laboratory at Berlin; and a description by Dr. P. H. Schaute of the physical laboratory recently established at Gröningen, in Holland. Lord Kelvin made some brief remarks, and Prof. Rücker made a few observations about the work done at Kew. Prof. Fitzgerald, Sir G. Stokes, and Prof. Ayrton took part in the discussion, in which very few important arguments were adduced, and Dr. Oliver Lodge replied. The endowment of research, and this particular research after an endowment, appear as far off as ever.

It is a pity that Prof. Blyth, who has been experimenting seriously with windmills for driving dynamos, has not been able to arrive, as yet, at any idea of what Mr. Swinburne would call the time-integral of the power, or, in plainer language, the total horse-power hours that may be developed in a twelvemonth by a windmill of given dimensions and construction. In reply to an inquiry after the reading of his Paper at the British Association on Friday last Prof. Blyth could only say that during one week in May his mill drove a 4-horse power dynamo at half-power, and on two or three days, it ran "much faster," occasionally developing the full output. The fact that "13 cells were kept charged" is hardly a measure of success; and yet wind-power is too cheap to be overlooked. We have remarked on a former occasion that the question of first cost really decides the question, rather than the irregularity, which is a question of storage. In spite of all the gold medals that were awarded at the Crystal Palace "for batteries" the charging of accumulators is a poor way of storing energy. We have already suggested in these columns that wherever space for storage and a sufficient fall can be obtained, there is probably no better way of storing the power developed by a windmill than pumping water into a reservoir; a pump with a variable stroke would enable a mill to do good work both in a light breeze and in a stiff gale. Perhaps a better way would be to use a set of concentric or parallel plungers arranged in connection with a governor, so that in a light wind only the one would work, the others being locked to the barrel. With stronger wind, the other plungers would become locked to the connecting rod, and thus nearly the whole available power might be used with a nearly uniform, or with the most

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efficient velocity of the sails. We understand that Prof. Blyth finds it possible to run an arc lamp fairly steadily with his windmill.

Prof. Hele Shaw's report on "Graphic Methods" will no doubt be consulted with great interest by electrical engineers when it is published; and judging from the abstract, which we hope to print in an early issue, not only the copious bibliography of the subject which forms a large portion of its contents, but the valuable generalisations of graphic methods which it contains will be greatly appreciated. Graphical methods are generally invented only when they are wanted, often by men whose algebra is too rusty for analytic work, and very little systematic arrangement has been attempted. The subject has, in fact, received next to no really scientific treatment.

It would be a convenience if some short name could be found for vacuum tubes without electrodes. These were referred to by several speakers at the British Association, both in Papers and in discussion. They have been used for years; but it will be conceded, even by those who, like Dr. Bottomley, have used them largely, that before Tesla's experiments not much attention had been paid to them, and it can be denied by none that he has outstripped all in the brilliant effects which he has produced. The word "vacuum tube" has become more common than "Geissler tube"; but why not use the name "Tesla tube" for one without electrodes, leaving vacuum tube to include both kinds?

The arrangements and organisation of Sections A and G, which are practically the only Sections of the British Association which deal with electrical subjects, have been no better than usual. The Secretaries who have acted in former years have been assisted by several local members, four being allotted to Section A, which deals with mathematical and physical science, and five to Section G, which deals with mechanical science. No attempt was made to give more than a suggestion of the subjects which would be dealt with on different days; but other Sections, such as the Geographical and Geological Sections, published very full lists of the proposed Papers and the names of the authors. No pressure had been brought to bear upon authors to send in their Papers before the meeting, and but few abstracts were to be obtained. The details which would go to make the task of sitting for hour after hour in these meetings endurable, such as the systematic supply of Abstracts or Papers to those who want them, the proper darkening of the room during experiments, the provision of proper chalks, the announcement during discussions of the names of speakers, and the suppression of talking and other unnecessary noises, are simply ignored. Notice boards outside each room were provided as usual for announcing the number of the Paper which was being taken at any time; but, as usual, these were hardly ever used, nor were they even employed to announce that the meeting had been adjourned.

The Sectional Meetings of the British Association, so far as Physics and Engineering are concerned, appear to be intended mainly for the members of the committees. Outsiders are invited and indeed urged to send Papers, and are allowed to take part in the discussions; but, although it is they who contribute the bulk of the funds, their convenience is neglected, and but little trouble is taken to render the proceedings attractive to them. The committees seem to be afraid of enforcing any of the ordinary regulations of scientific societies, and allow one or two eminent men, who cannot be bothered in holiday time to write their communications, to prevent any orderly arrangement of Papers. As to the programme for the next day, the members of committees can, if they care to attend, inform themselves about it in good time, and the Secretaries are of course acquainted with it; but the programme for the day, as far as outsiders are concerned, is not published until the same morning, causing the greatest inconvenience to the ordinary members. There is no reason why it should not be posted in the room, and in the reception room as soon as it is decided upon.

There are, however, Secretaries and Secretaries. The work done by Mr. Glazebrook and by Prof. Hele Shaw in the preparation of the reports of sub-committees is comparable with the best work of any scientific societies. These reports have a most important and lasting value, and they are in strange contrast with the advertising Papers and half-finished communications from students and faddists which often occupy the time of the Sectional Meetings. A description of a flying machine may appeal to a crowd of holiday makers, but such sketchy performances are hardly a fitting foil to the solid work of the reports, which is apt to be lost sight of among them.

Considering that the City and South London Railway is not only a new concern, but is a new concern worked in a novel manner, the progress it is making towards a steady dividend-earning position is sufficiently rapid. Compared with the corresponding period of 1891 there has, during the past half-year, been a 20 per cent. increase in the number of passengers carried, and a 9 per cent. increase in the gross receipts, while expenses are less by some 3 per cent. The best evidence that the Company is being managed on sound lines is that afforded by the items grouped together in the accounts in Abstract B., "Locomotive and Generating Power." Here we see that in spite of an increase of nearly 9 per cent. in the train mileage, viz., from 174,435 for the first half-year of 1891 to 188,944 for the corresponding period of this year, the running expenses have come down by 13 per cent., viz., from £6,148 to £5,360; wages and coal both showing substantial savings. The locomotive expenses, which were 9d. per train mile when the line commenced working, are now only 7·7d. The happy idea of building a gallery round the engine-room at Stockwell and levying a tax upon the curiosity of the public may be commended to central-station companies in quest of a dividend.

The financial result of the first quarter's working of the Brighton municipal electric light undertaking is not altogether unsatisfactory; especially in view of many of the circumstances which attended the inception and carrying out of the

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scheme. The sale of electricity at 7d. per unit, together with meter rents, realised some £840, while the total outgoings amounted to £582; leaving a profit on the first quarter of £250, after making some provision for bad debts. This profit, it is true, is converted into a deficit of £283 10s. 6d., owing to the necessity of setting aside moneys for interest and sinking fund. It is also true that interest on capital during construction amounting to £370 has been charged to capital account, as well as £2,100 under the head of general expenses. But this mode of procedure is not peculiar to the Brighton undertaking, and on the whole there seems to be good grounds for anticipating before long a more evenly balanced state of things.

Personal.—Mr. W. H. Brownlee, of Glasgow, has been appointed electrical engineer for the city of Dundee.

Bristol.—Owing to the bricklayers' strike it is not now anticipated that the supply of electricity will be available this winter.

Durham College of Science.—The Autumn Session of this College commences September 26th. For further particulars see our advertisement columns.

River Cables.—The Indian Telegraph Department have recently laid three more cables across the Irrawaddy. There are now in all eight cables crossing it.

Colchester.—At the last meeting of the Town Council it was agreed that the Lighting Committee should be empowered to take proceedings for obtaining a Provisional Order.

Southport.—The Gas Committee have recommended that application be made to the Local Government Board for power to borrow £28,000 for the purpose of carrying out an electric lighting system.

Appointments in Cable Companies.—In the list of appointments given last week that of Mr. William Hibberdine to be Traffic Accountant of the Eastern Telegraph Company, in place of the late Mr. Lewis Wells, was inadvertently omitted.

Coast Telegraphic Communication.—The Post Office cable steamer *Monarch* arrived at Scilly on Tuesday last week, and commenced the work of connecting the coastguard stations at St. Mary's, St. Agnes, Bryher, Tresco, and St. Martin's.

Electrical Standards.—On p. 372 (line 22 from the top) of our last issue, "the pull between two parallel surfaces joined by a weber is $10^{16}/6\pi$ dynes, or 400,000 tons," should read as follows: "The pull between two parallel surfaces *of one square centimetre area.* . . ."

Electric Lighting Notices.—The Works Committee of the Limehouse Board of Works have had under consideration the notice of the City of London Electric Supply Corporation, that they intend to apply for a Provisional Order. They recommended that the application be opposed.

Yarmouth.—At the last quarterly meeting of the Town Council the Town Clerk reported that he had received tenders for an electric light installation for the town from several firms. The tenders varied between £5,000 and £6,000 to £23,000. These were referred to the Electric Light Committee.

Berlin.—The Allgemeine Elektricitäts Gesellschaft of Berlin are proposing to erect a central station in the suburbs of Berlin. The kilowatt hour for lighting purposes will be charged at the rate of 6¼d., and for power purposes at the rate of 1¼d. Rebates will be given to large consumers. Separate meters will be installed.

Melbourne.—The contract for supplying the machinery and apparatus for the electric light installation has been secured by the Thomson-Houston Electric Company, and that for supplying the boilers by the Babcock-Wilcox Company. The cables and wires are, our readers will remember, to be supplied by the International Okonite Company.

Barnsley.—At a recent meeting of the Town Council the consideration of the recommendations of the Park and Lighting Committee, that the electric light should be installed on a site in Beckett-square, at an estimated cost of £18,382, and that application should be made to the Local Government Board for sanction to borrow the said sum, was deferred.

Tanning by Electricity.—A company has been formed at Barcelona, says *Industries*, to establish a tanning factory by electricity on the Groth system. Should the new factory prove successful many others will doubtless be established in Spain, particularly at Valladolid, Seville, Saragossa, Valencia, and other such towns, where the tanning industry is now carried on.

Blackburn.—The Gas Committee of the Town Council have ordered the preparation of detailed estimates, plans and specifications for the proposed electric lighting works, and have decided to recommend the Town Council to make application to the Local Government Board for sanction to the borrowing of £50,000. A suitable site for a central station is also to to be selected.

Obituary.—We regret to record the death at Christiania, in his 74th year, of M. Carsten Tank Nielsen, Director-in-Chief of Norwegian Telegraphs. M. Nielsen was the *doyen* of the International Telegraph Conference, having attended the first Telegraph Conference held in Paris in 1865, and he was presented with the order of Commander of the Legion of Honour of France at the last Conference, held in Paris in 1890.

Aluminium Plating.—With reference to the statement which Mr. Swinburne makes in his Paper on "The Problems of Commercial Electrolysis," that "it seems to be impossible to deposit aluminium from any of its solutions . . . ." (see *The Electrician*, August 5th, p. 368), M. Van Beete, of the Maatschappij tot Exploitatie van De Brakke Grond of Amsterdam, sends us an iron screw plated with aluminium in aqueous solution at ordinary temperature.

Earth Currents.—Mr. C. P. O'Reilly writes us from Bombay to the effect that earth currents were on the telegraph wires in that neighbourhood on July 12th, 13th, 16th and 17th. The currents were most felt on wires running S.E. and W.N.W. and occasionally lasted for several hours at a time, sometimes attaining a strength of 10 milliamperes. Our correspondent calls attention to the fact that these disturbances took place at the same time as eruptions at Etna and Sangir, and he states that a high wind and squally weather also prevailed.

Lightning.—An inquest was held at Fareham last week with regard to the death of a bricklayer from lightning on Saturday, 30th ult. On the same day a storm passed over Wimborne; and some sheep were killed. They were standing near a fence composed of stout oak posts and wire. Many of the posts, which were eight inches thick, were shattered in the most extraordinary manner. Splinters of the wood were scattered 40 yards from where the posts were standing, and a staple used to fix the wire to the posts was driven 45 yards from the wire. Some of the posts were split clean in two, whilst others had furrows ploughed in them.

Electricity in Mining.—On Friday last week the annual general meeting of the South Wales Institute of Engineers was held at Cardiff, and Mr. Albion T. Snell opened a discussion on a Paper on Electrical Work in Mines, read by him at a previous meeting. In the course of the discussion, Mr. Archibald Hood said he did not think there was a more important subject they could discuss than the transmission of power underground by electricity. Since he had employed it he had determined to increase it. He had half-a-dozen pumps working underground by electricity, and the results in every case were highly satisfactory. There was a wide field of application for electricity, and he had no doubt the time would come when engineers would succeed in preventing anything like liability to explosion.

Glasgow.—The Gas Supply and Electric Lighting Committee have presented their annual report and balance-sheet to the Town Council for the year ending May 31, 1892. After making the usual provisions in regard to sinking fund,

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&c., and depreciation, there remains a deficiency on the year's operations of £26,000. The Committee recommend that the price of gas should be increased from 2s. 6d. to 2s. 9d. per thousand. No accounts with regard to the electric lighting undertaking are presented by reason of its recent commencement. It is hoped that a supply of current on the low-pressure system will be available before the winter sets in.—The Town Council have accepted the tender of the Brush Company for the supply and erection of series arc dynamo machines and lamps for public lighting, in accordance with the specifications drawn up by Prof. Kennedy; and the tender of Messrs. Easton and Anderson for the engines.

Electric Traction in Germany.—In regard to the statement published on page 161 of our issue of June 17th, to the effect that the then recently opened electric tramway at Bremen was the first in Germany to be operated upon the overhead trolley system, the Allgemeine Elektricitäts Gesellschaft of Berlin write to us to point out that this is not the case, as the Halle tramways have now been worked with an overhead wire for a considerable time, and with such success that important extensions are now in progress. In February of this year also the electric tramway at Gera, equipped by the same company for Messrs. Vering and Wächter, was handed over to be worked. The satisfactory results of working these two lines electrically have raised electric traction in Germany, they inform us, above the experimental stage, and created so much confidence that the Allgemeine Elektricitäts Gesellschaft have now in hand two large lines—one for the Berlin Lokal und Strassenbahn Gesellschaft, situate at Chemnitz, and the other, which has a total length of about 18 miles at Breslau, for the Aktiengesellschaft Elektrische Strassenbahn, Breslau.

The Action of the Electric Discharge on the Atmosphere.—In a recent issue of *Wiedemann's Annalen* Dr. V. Lepel publishes an account of an investigation of his on the oxidation of nitrogen by the electric spark, and his conclusions are interesting in the light of Prof. Crookes' theory, referred to in an Editorial Note, on p. 211 of our issue of July 1st. It is well known, says Dr. Lepel, that the passage of high-pressure electric discharges through damp air is accompanied by the formation of small quantities of nitrous and nitric acids (HNO_2 and HNO_3), which form ammoniacal salts in air. The first action of the discharge seems to be the production of nitric oxide (NO), which is immediately converted into peroxide (N_2O_4). This latter reacts on the vapour of water, to form nitric acid, liberating nitric oxide. Nevertheless, it has been observed that sparks passing through gaseous oxides of nitrogen decompose them into their original elements. Hence, as a consequence in a given space, a limit is soon reached when no more nitric acid is formed. Dr. Lepel has experimented with a slow current of air, under different pressures and with different kinds of discharge, and has succeeded in increasing the production of nitric acid to 10 per cent. of the total quantity of air employed. He considers it probable that by means of high-pressure discharges nitric acid may be made from the atmosphere on a commercial scale.

Oldham.—An inquiry was held at Oldham on Friday last, before Colonel Hasted, R.E., the inspector appointed by the Local Government Board, in reference to the application of the Corporation for borrowing powers not exceeding £40,000 for electric lighting purposes. The Town Clerk said that on April 28, 1887, the Corporation acquired a plot of land adjoining the railway, situate at Rhodes Bank, which they propose to utilise for the electric lighting station. Nothing further was done by the Corporation until the Session of 1890, when they obtained a Provisional Order. In February of this year the Corporation retained Prof. Kennedy as their electrical engineer, and he had devised a scheme for the Corporation. The plant proposed to be put down would supply simultaneous lighting for about 2,500 lamps of 8 c.p. each. The system was to be two-wire low pressure. The engineer's estimate of the cost of the works to be carried out forthwith was, exclusive of land, £21,000. The Corporation anticipated that close upon 2,000 lights would be taken up immediately. The Corporation thought thirty years would be a reasonable time in which to be allowed to repay the money. Prof. Kennedy then explained details as to the site of the works and the cost. The scheme was so arranged that the two-wire system could be changed to three-wire if the demand required it. The cost he estimated as follows:—The plant, including everything stationary, £8,800; the mains, £5,600; the buildings, £6,000; the meters £600. The inquiry then concluded.

Brighton.—At the meeting of the Town Council on Saturday last the Lighting Committee presented their statement of accounts relative to the first quarter's working of the electric lighting system, from September 15th to December 31st, 1891. The sale of electricity, at 7d. per unit, realised £831. 10s. 3d., and £8. 5s. rent of meters brought the total revenue up to £839. 15s. 3d. The cost of generation amounted to £391. 18s. 10d., and management expenses amounted to £173. 3s. 7d. Rates, taxes, and insurance raised the total outlay to £582. 5s. 11d. After setting aside a sum of £7. 9s. 4d. for bad debts, there remained a balance of profit of £250. Two sums of £290. 18s. 6d. and £242. 12s. were, however, required respectively for interest and sinking fund in respect to the original outlay. These two sums amounted to £533. 10s. 6d.; and after deducting the £250 brought forward from the revenue account, there remained a deficiency of £283. 10s. 6d. Alderman Moon explained the accounts, and stated that they made a start with only four customers, but gradually raised the number during the quarter to 82, for the supply of 2,374 lamps; but it had to be borne in mind that some of those were only supplied for three or four days at the end of the quarter, so that it was manifestly unfair to draw any conclusions from their first quarter's trading. They were now supplying 3,715 lamps out of the 10,000 provided for, and he had perfect confidence in saying that in two years' time they should be working at a profit, enabling them either to apply a surplus to the rates or to reduce the cost. After this explanation all opposition was withdrawn, and the accounts were adopted *nem. dis.*

The Electric Lighting of Railway Carriages.—We are informed that a contract has been entered into between the Railway Electric Reading Lamp Company and the Metropolitan District Railway Company to instal upwards of 10,000 reading lamps in the carriages of the District Railway. We are given to understand that similar contracts are being negotiated with other railway companies. It is not intended at present to displace the gas lamps in use in the roofs of carriages, but to provide a separate light for passengers desiring to read. The mechanism by which this will be accomplished is contained in a box 5in. by 3in. Upon introducing a penny into the slot at the top of the machine and subsequently pressing a knob, an electric light is obtained which burns for about half an hour, at the end of which time it is automatically extinguished, but can be relighted by the insertion of another penny. The light, which is of about 3 c.p., is concentrated by a shaded reflector, which may be turned within certain limits, so that the light may be directed to suit the position of the passenger. The instrument is so arranged that in case of a failure in the supply of electricity, the machine automatically returns the coin to the operator. Another feature is that, should the lock of the apparatus be tampered with, a bell is automatically set ringing in the guard's van. It is proposed to place these lamps under the hat rails in railway carriages, so that the passengers seated in the corners, and thus farthest from the roof light, may be able to provide themselves with additional illumination. The whole of the lamps placed in one carriage are supplied with current from an accumulator placed under one of the seats of the carriage. The lamps are to be worked at 12 volts, and will require about 0·75 ampere. The accumulator has been specially designed for the work, and consists of six cells, coupled in series, having a capacity of 72 ampere hours. A charging station is to be erected at Mill Hill Park, on the District Railway, and sidings are to be made in the station for the reception of a number of trucks on which the accumulators will be charged and removed. Early in the morning trucks containing the charged accumulators will be forwarded from the charging station to the various distributing termini, where they will be changed as required during the day; and then at night the trucks will return with the exhausted batteries.

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PROF. EWING'S MAGNETIC CURVE-TRACER.

At his evening lecture before the British Association on Monday, and again in Section A on the following day, Prof. Ewing exhibited his apparatus for automatically drawing magnetisation curves.

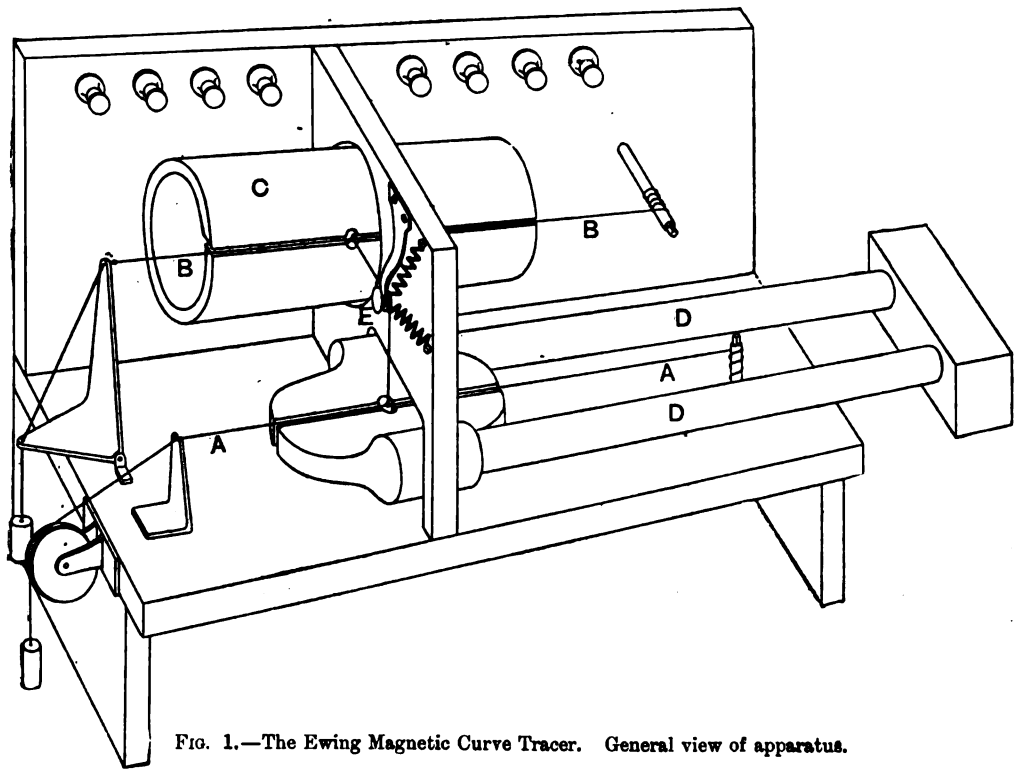

FIG. 1.—The Ewing Magnetic Curve Tracer. General view of apparatus.

This instrument is a practical magnetic tester, which will allow the makers of dynamos or transformers to test their iron with the greatest ease, and will allow different samples to be compared for permeability, hysteresis, and other magnetic characteristics with the rapidity and simplicity necessary in workshop tests. The instrument combines, in a single piece, a novel form of galvanometer with a novel form of magnetometer, and the indications of both are given by a single mirror, which receives a horizontal motion proportional to the magnetising force, and a vertical motion proportional to the magnetisation. A spot of light reflected from the mirror in the usual way traces out the curve of magnetisation on a screen consisting of a sheet of squared paper. The mirror is so dead beat with respect to both of its component movements that a cycle of magnetisation may be gone through in a fraction of a second.

The principle of the apparatus will be seen by reference to Fig. 1, which, it should be understood, is a mere diagram, and does not exhibit the details of construction. E is the mirror which is mounted on a single needle point in such a way that it has two degrees of freedom for deflection. It receives azimuthal movement from the wire B B, which is lightly stretched in a narrow gap in a magnet C. This magnet is a piece of iron pipe with a longitudinal slot cut in it, and is magnetised by means of a longitudinally wound coil, so that the lines of force jump across this slot, in which the wire B B is strung. The mirror at the same time receives altitude movement from the wire A A, which is stretched in a narrow gap between the pole-pieces of a magnet D D. The magnet D D consists of the samples which are to be examined, united at the back end by a yoke-piece of soft iron. A constant current is kept up in the wire A A, and it there-

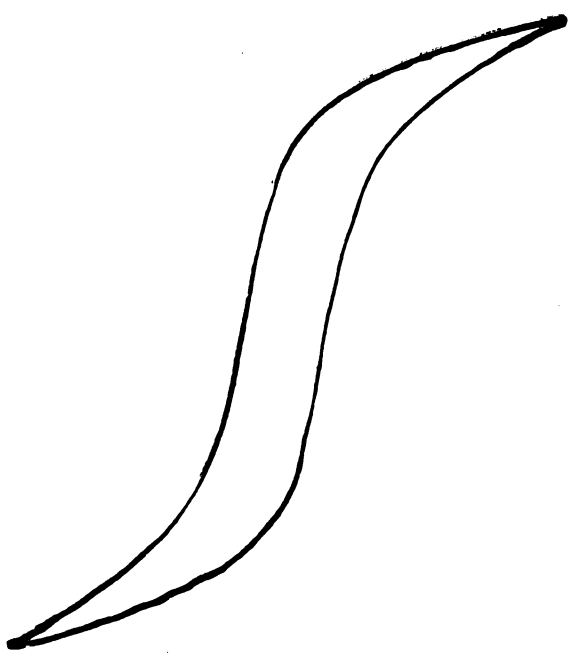

FIG. 2.—The Ewing Magnetic Curve Tracer. Sample plain hysteresis curve.

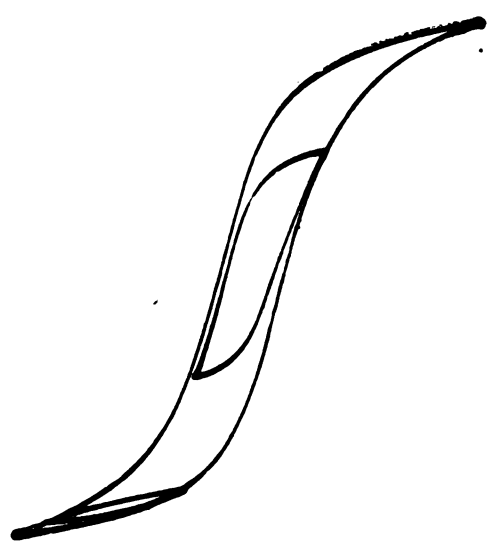

FIG. 3.—The Ewing Magnetic Curve Tracer. Sample hysteresis curve with loops.

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fore sags up or down proportionally to the variations of magnetism in the rods D D. These rods are surrounded by magnetising coils, and the current for them passes also through the wire B B, which, as has just been said, is stretched in a constant magnetic field. It consequently sags out or in, giving horizontal deflection to the mirror, by amounts which are proportional to the magnetising force in the coils of D D. Hence, to describe a magnetising curve for the rods D D it is only necessary to apply a gradually-increasing current to the coils of D D, when the mirror takes vertical movement proportional to the magnetism and horizontal movement proportional to the magnetising force, and by reducing the current to zero, reapplying it, reversing it, and so on, all the magnetic characteristics of the material are rendered obvious at a glance.

Prof. Ewing has arranged the apparatus so that a complete cycle of magnetisation—the usual cycle of double-reversal—can be gone through in one-tenth or even one-twentieth of a second; and this allows the spot of light to trace a curve which appears as a continuously luminous line—an experiment which was shown in his lecture. In the use of the instrument as a practical magnetic tester it will, however, generally be preferred to trace the curve more slowly, following with a pencil the movement of the spot of light, and so obtaining a permanent record. A simple variation in the form of the pole-pieces and yoke allows sheet-iron or wire to be tested instead of solid turned rods. It was shown by actual experiment at the lecture that a complete cycle could be obtained for a given specimen in a few seconds; then another specimen was put in, and its curve projected just above the previous one, so an immediate and at the same time complete comparison of the two could be made.

The curves shown in Figs. 2 and 3 are reproduced from photographs of magnetic cycles taken by means of this instrument, using laminated iron specimens, the light spot being reflected directly on to the sensitive plate. The plain cycle (Fig. 2) is one of a series which were taken at the rate of two cycles per second; the plate was exposed 15 seconds, so that the curve was traced over 30 times. The little ripples due to the inertia of the working parts reproduce themselves in the same places every time. Fig. 3 is a photograph taken while the current was varied by hand in such a way as to superpose two smaller loops on a main cycle of reversal.

In exhibiting the instrument in Section A, Prof. Ewing points out further uses to which the apparatus could be adapted as an exceptionally dead-beat galvanometer, and also as a phase-meter and as an analyser of alternate currents.

SECONDARY BATTERIES IN USE AT THE CENTRAL TELEGRAPH OFFICE, LONDON, FOR TELEGRAPHIC PURPOSES.*

BY W. H. PREECE, F.R.S.

In a Paper entitled "The Use of Secondary Batteries in Telegraphy," communicated to the British Association at the meeting held in Montreal, in 1884, I gave an account of a series of experiments which had been carried on during the preceding twelve months, to determine the suitability of secondary batteries for telegraphic purposes. In the same Paper, after giving a number of calculations as to the financial side of the question, I ventured to predict that secondary cells would soon be made the most economical of the sources of electrical energy for this purpose.

Since that time the use of secondary batteries has been extended, and for the past seven years they have been used to supply current to two large groups of circuits, one group consisting of 110 single needles, and the other of 100 Morse inkers and sounders.

To provide a ready means of replacing the battery in case of failure, the leads from the working and reserve cells, which are placed in the basement, are first led up to the test-board in the instrument room, and there joined to a switch, thence the leads are again led to a test-board in the battery room, where the two groups are split up into sub-groups of ten circuits each. The connections are made in this manner for two reasons, first, for facilitating a change of a faulty battery; and, second, to prevent a general stoppage of the whole group in the event of a short circuit at any of the instruments; the resistance of the leads between the instruments and the sub-dividing connections in the basement being sufficient to prevent more than three amperes being taken from the battery by any one of the instruments even when a short circuit is on. To prevent any damage to the instruments, or risk of fire, fuses are placed in the battery leads at each instrument. The circuits on the groups mentioned are all metropolitan, and are all, approximately, of the same resistance, no equalising resistances being, therefore, necessary. The current in each circuit ranges between 17 and 20 milliamperes. The E.M.F. for the single needles is 20 volts; ten cells positive and ten cells negative, with earth in the centre. For Morse working, the E.M.F. is 18 volts. The connections are shown in Fig. 1.

In addition to these two groups another set of 22 cells has been in use since 1889, supplying current for driving the motors of the Delany Multiplex Distributors. Each of these motors requires a current of about 0·12 ampere, and there are ten of them at present driven from this source. Fuses are placed in the leads to each motor. There is no spare set for this work. A considerable extension of the accumulator system has recently been made, advantage being taken of the transfer of all the Continental service to the General Post Office building in St. Martin's-le-Grand. This transfer was made on October 17, 1891, and since that date the whole of the Continental circuits have been operated by currents from secondary cells. There are 59 of these Continental circuits, and as they are of various lengths, some requiring repeaters in England, whilst others go direct to the Continent, a somewhat different arrangement has been adopted. In addition to these varying conditions, it was found impossible to use the same polarity to all countries. The German, Dutch and Belgian lines taking positive, and the French negative. It was also necessary to provide an arrangement which would cause the stoppage of the minimum number of lines should a main fuse be burned or a battery fail.

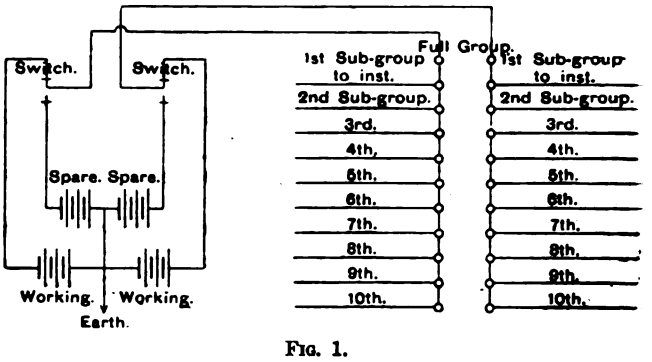

FIG. 1.

The 59 lines are divided into four groups, but as the force required for these long lines is 100 volts it is evident that the risks of allowing a dangerously heavy current passing out from the instrument to line, should it make earth near the sending station, is increased. To provide against this, resistances of 100 ohms are placed in the battery leads at each instrument, so that it is absolutely impossible that more than one ampere can flow even with earth on the line close up to the instrument. Independent 3-ampere fuses are also fitted to each instrument, to prevent any damage to lines or instruments, should the safety resistance be short-circuited. As it is sometimes necessary to put repeaters in on the English side of the cable on some lines which nominally work direct to the Continent, the resistance blocks on several of the instruments are wound to 1,000 ohms, and fitted with a switch which enables either 100 ohms or 1,000 ohms to be inserted in the battery circuit, and thus the current is kept constant. In addition to the independent 3-ampere fuses, main fuses to break at 10 amperes are placed on each group of circuits in the accumulator room.

* Paper read before the British Association at Edinburgh, in Section G, August, 1892.

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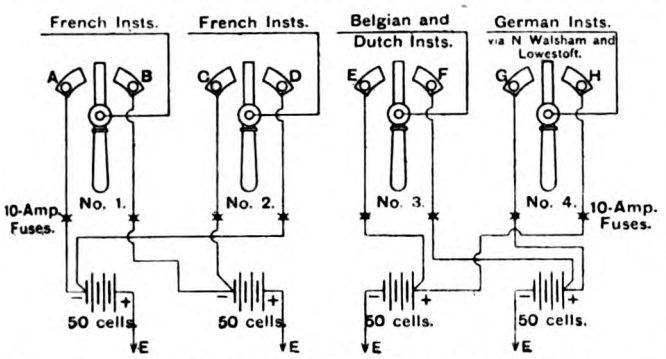
The arrangement of the connections in use on the Continental lines is shown in Fig. 2. All the cells are kept well charged, and the E.M.F. is not allowed to fall below 1·95 volts per cell. Where spare or reserve sets are provided the charging is carried on at any convenient time, and on those where no



100 ω resistance in each Branch Lead to French, Belgian and Dutch Instruments.
100·0 ω „ „ „ „ German Instruments.

FIG. 2.—Connections of Secondary Cells for the Continental Gallery.

spare sets are in use the charging is done at night, when the minimum disturbance is caused by the slight increase of E.M.F., which is inseparable from simultaneous charging and working. Accumulators are also used for working the Paris telephone circuits. Their E.M.F. is so constant that they are found to be eminently adapted for the purpose.

ON THE EFFICIENCY OF TRANSFORMERS.*

BY M. VON DOLIVO-DOBROWOLSKY.

(Concluded from page 371.)

The cardinal virtue of the transformer is unquestionably its high efficiency. But efficiency, when applied to transformers distributed in installations or in central stations, has a different meaning to that usually accepted in the case of dynamos and motors. The loss which takes place in a transformer must be distributed over the whole daily working period, probably twenty-four hours, during only a relatively short portion of which time, even in winter, does the full load come on. By the average efficiency of a transformer we are to understand, then, the ratio of the all-day useful output in watt hours to the watt hours delivered to the transformers. It is true that by this mode of computation the efficiency will depend upon the curve of current consumption during the day, the unfavourable effect of which the transformer builder cannot help. It is, however, possible to plot a curve of the mean all-day consumption for separate localities or towns, and on that basis to determine approximately the all-day efficiency of the transformers, and to arrange their construction accordingly. Figs. 6 and 7 illustrate, for example, the current consumption respectively in Berlin and in a provincial town; in the latter there is no electric motor work during the day-time. From an examination of these load curves we see that the efficiency of the transformers at maximum load has a barely perceptible effect upon its average efficiency, and that the chief trouble is the loss at light loads.

The losses in the transformer are twofold: (1) those due to the copper resistance, called the "copper loss"; (2) those that take place in the iron, and, as mentioned above, caused, for the most part, by hysteresis, and called the "iron losses." The copper losses increase as the square of the current; and if the exciting current is small, as is usually the case, we may approximate proportionality between current and load. It comes, then, to this—that the copper losses rise and fall as the square of the load. For instance, if the copper loss at full load is 100 watts, at half load it will be only 25 watts; at one-tenth maximum load only 1 watt. The copper loss has, therefore, but little effect upon the average efficiency of the transformer, light loads only being of account in this connection. The iron losses, however, like the magnetism, are constant for the whole range of the transformer's capacity. They become, therefore, the more important the smaller the load, and *vice versâ*; so that in order to obtain high average efficiency during the day-time, it is necessary to keep the iron losses small.

A transformer may always be graphically illustrated, as in Fig. 8, namely, as two tightly interlocked links, one of copper, the other of iron. It is not possible to increase the cross-section of one of these links without increasing that of the other. The misfortune with transformers is that we cannot increase the copper cross-section, and so reduce the resistance and copper losses, without at the same time increasing both the volume of the iron and the iron losses. But the net outcome of this is that, as the copper losses only slightly affect the efficiency, it is possible, by allowing a comparatively large

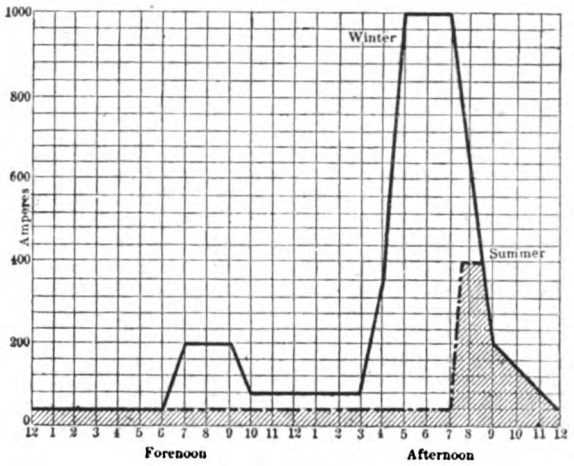


FIG. 6.

copper loss, to do with a small volume of iron, and thereby obtain a high all-day efficiency. The only disadvantages of large copper losses are that in central stations with a growing load an additional electromotive force of several per cent. must be provided. This would tell somewhat against such a device, were it not that we are accustomed to this with almost all systems of the distribution of

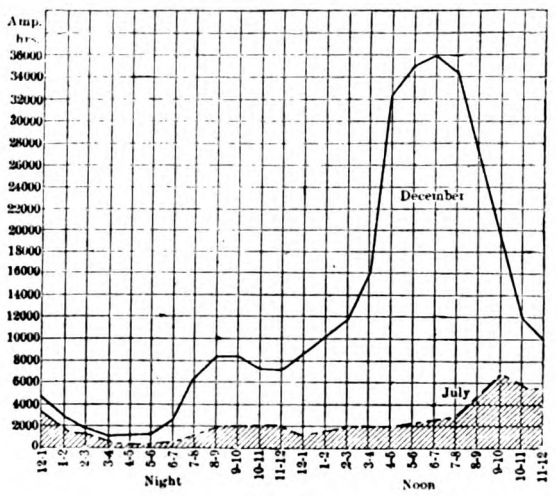


FIG. 7.

electricity. Continuous-current stations are more easily operated with a pressure on the feeders some 20 per cent. higher than the distribution pressure. Moreover, it seldom happens that less than 2 per cent. or 3 per cent. loss takes place in the long-distance circuits of a high-pressure alternating-current system; this, with the addition of the 2 per cent. loss in the transformers, gives a total loss of volts

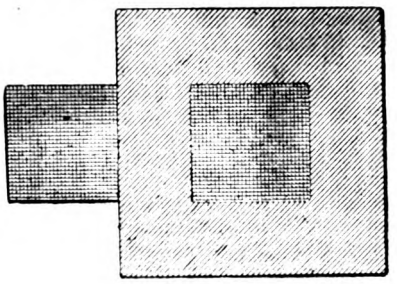


FIG. 8.

of at least 5 per cent., apart from the small fall of volts due to the magnetic leakage of the transformers. This 5 per cent. has even now been compensated for. Why, then, is it not possible to make up for more, for instance, for 7, 8, or 10 per cent.? This fall of volts, moreover, is still smaller than that which usually obtains on continuous-current systems, and regulation of some sort cannot

* A Paper read before the Electrotechnic Society of Berlin, March 22, 1892.

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be dispensed with in any case. The idea that it is sufficient with an alternating-current system to keep the station voltage constant has long been abandoned. I propose, therefore, to break with the traditional 2 per cent. potential loss in transformers, and to assume something like 4 or 5 per cent. as the normal, especially where it is not the maximum efficiency but the all-day efficiency that is of importance. More coal may be saved by this means than one would imagine.

A further question is whether iron losses may not be lessened by certain modifications in the constructive arrangement of transformers. If we have a certain quantity of iron, and a given magnetic density, we shall always have the same iron loss for the same frequency. This loss is independent of the shape of the iron. How shall we arrange our iron in order to obtain from it the largest possible amount of transformed energy? The answer to such a question cannot be other than that the given quantity of iron must be disposed, so far as possible, in such manner as to provide as much room as possible for the copper winding. As a matter of fact, the "window," or the opening for the winding, is in the case of thick rings disproportionately small. Nor must we go too far in arranging the iron in a thin broad ring, as, in consequence of the ever-increasing periphery of the copper coils, the output increases at a slower rate than the weight of copper, and the transformer would become too expensive. Nevertheless, it is always advisable to give the iron such a form that a lot of copper can be employed, for the price of the transformer might easily be more than double the present average price, if a material saving in running costs could be effected thereby. As an increase in the cross section is accompanied by a less rapid increase of periphery, large transformers can be built more efficiently than small ones. It is impossible to give too urgent a warning, therefore, against the American practice of using a transformer in every house, be it ever so small. The saving in wire is nothing as compared with the increased running costs. In distribution systems, where economy is of prime importance, only a few transformers of under 5 kilowatts should be employed; and I believe that soon the average size of a transformer will be at least 20 kilowatts. The objection that very large transformers have not sufficient cooling surface I would meet by citing the example of the largest transformers ever made, namely, those on our Lauffen-Frankfort installation. These transformers have been at work for days at a time, as was the case when the trials of the Testing Committee were being carried out, and their temperature did not rise more than 40° C. This was so with the transformers of the Allgemeine Electricitäts Gesellschaft, as well as with those of the Oerlikon Company.

I again take the liberty of comparing these new views on transformers with those hitherto generally accepted:—

(*a*) *Old View.*—The magnetic circuit must, if possible, have little resistance; the iron must be short, thick, and, if possible, without joints. *New View.*—The magnetic resistance is of little importance; joints may be made in view of constructive considerations (indeed, they are desirable at times in order to oppose the electrostatic capacity of the circuit); the iron cores must be relatively long and thin, in order to leave plenty of room for copper.

(*b*) *Old View.*—The copper must, if possible, be surrounded with iron—it should even be embedded in iron where possible—in order to save copper. *New View.*—The iron must, if possible, be surrounded with copper, in order especially to save iron.

(*c*) *Old View.*—The transformer must be self-regulating, and to this end the coils must have as little resistance as possible. *New View.*—Do not try to obtain self-regulation, as this is illusory, owing to the losses in the circuit. The resistance of the transformer, so long as it is not excessive, has little effect upon the average efficiency, and if we increase the copper resistance with the object of reducing the iron mass, the economy may even be improved.

In order that your faith in the possibility of thoroughly good transformers, that will also work economically at light loads, may be strengthened, and by way of illustrating my principles, I will bring forward some actual examples, and these examples refer to transformers specially designed by the Allgemeine Electricitäts Gesellschaft for distribution purposes. Fig. 9 represents an alternate-current transformer of 3,500 watts capacity at 80 alternations, transforming down from 1,000 volts to 100 volts. The actual iron cross section amounts to 42 square centimetres, after making allowance for the insulation. Number of high-pressure turns, 3,600; low pressure, 360. The high-pressure copper wire is 2·3 mm. diameter (4·1 square mm. cross section), and the low pressure 5 × 8 mm. rectangular wire (cross section owing to rounded corners 38 square mm.). The resistances of the two windings amount respectively to 9·0 and 0·064 ohms when warm. This gives a total copper loss at full load of about 5·3 per cent. The weight of copper on the transformer comes to about 120 kilogrammes. The iron core 440 mm. long, with cross pieces 350 mm. long, suffices to take the above amount of wire with plenty of insulation, &c. The weight of iron is about 50 kilogrammes. With a density of 4,000 lines of force, and looking at the curve in Fig. 5, which may be considered as referring to moderately good iron, it follows that there is a no load loss of 50 watts = 1·4 per cent. of the transformer maximum

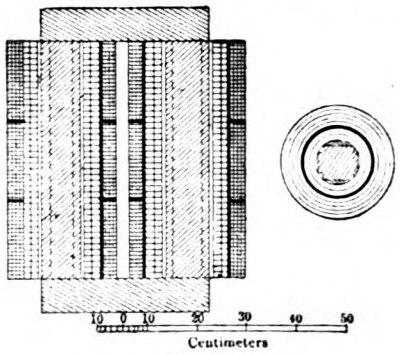

Fig. 9.

cap city. The efficiency curve and that of the total losses are shown as a function of the output in Figs. 10 and 11 respectively. The dotted lines represent the efficiency of and losses in a trans-

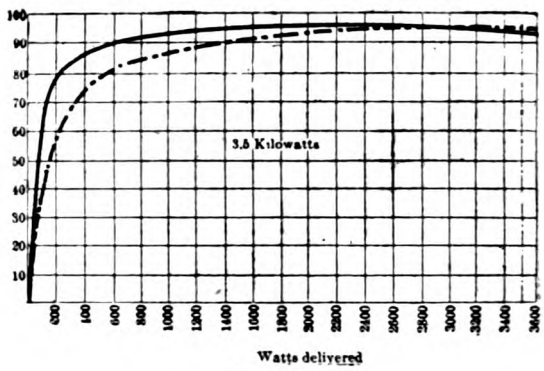

Fig. 10.

former of similar size designed on the old lines, namely, with only 2 per cent. copper loss against 4 per cent. iron losses.

Fig. 12 represents a bigger transformer, namely, one for 20 kilo-

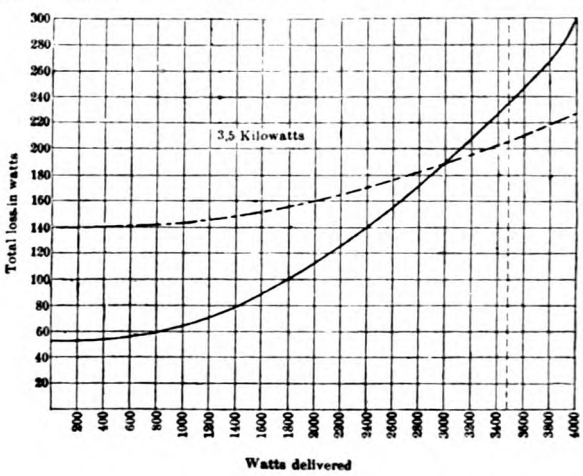

Fig. 11.

watts, transforming down from 5,000 volts to 100 volts, at 80 alternations. Both low-pressure coils have 76 turns of rectangular wires, 120 sq. mm. cross section; while the high-pressure coils are

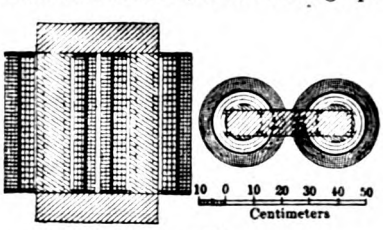

Fig. 12.

wound with 3,760 turns of 2 mm. wire, 3·14 sq. mm. cross section. The total resistances are: low pressure, 0·0121 ohm; high pressure, 34 ohms, when warm. The copper loss at full capacity is, therefore, about 5 per cent. The total weight of copper, in round

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figures, is 330 kilogrammes. From the iron sectional area of 110 sq. mm. it follows from the dimensions given in Fig. 12 that there is a weight of iron of about 160 kilogrammes. The magnetic density in this instance is also about 4,000. Assuming here, again, the same moderately good iron, we get a no-load loss of about 160 watts, or only 0·8 per cent. of the total capacity. Figs. 13 and 14 give the efficiency and losses curves respectively. Here, again, the curves for a typical transformer are given for the sake of comparison, the loss of pressure being assumed as 2 per cent. and the energy required at no load also at 2 per cent. We see in both sizes

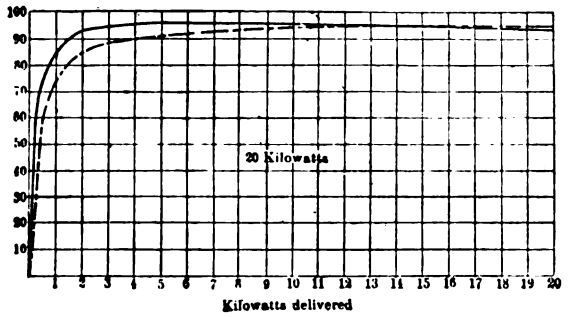

FIG. 13.

that the new type of transformer has less efficiency at maximum load than the old type. We will now deduce and compare the losses and efficiencies from the loss curves in Figs. 11 and 14, and

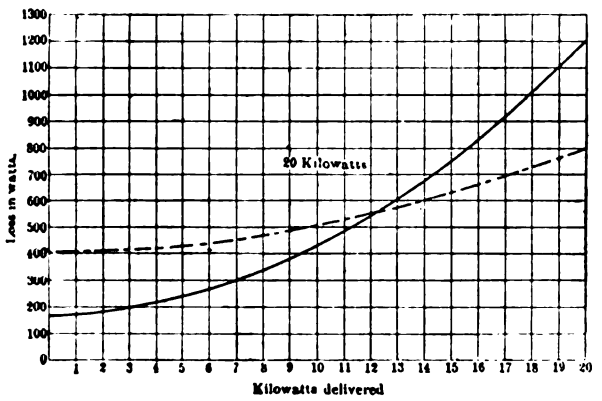

FIG. 14.

from all-day consumption curves of Fig. 6. Taking 1,000 amperes × 100 volts = 100 kilowatts, as winter maximum, we get the results shown in Table A.

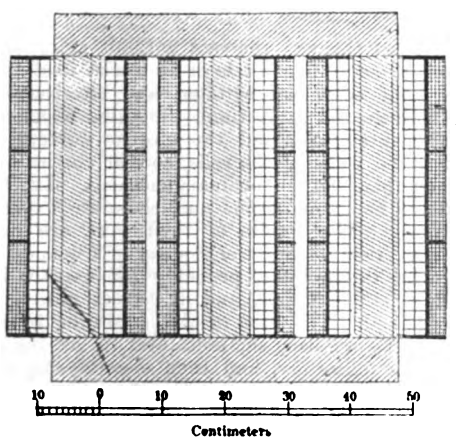

FIG. 15.

We see from this table not only the great superiority of the new method of designing transformers, but also that even when using them under the most unfavourable conditions, such as obtain when failing to cut out surplus transformers in the summer time, and when there are no motors during the day, the losses are still only of minimum amount, and there can be no question of their efficiency.

"Drehstrom" transformers, the latest arrangement of which I have shown in Fig. 15, are based upon the same principles as alternate-current transformers; and what has been said applies equally to both. I trust I have proved the very universal notion that transformer installations cannot pay—on account particularly of enormous loss during the daytime—to be without foundation, and with it the last prejudices against the introduction of the "Drehstrom" for long-distance transmission and distribution must disappear.

Table A.

—	Using transformers.			
	3·5 kilowatts.		20 kilowatts.	
WINTER.	Old type.	New type.	Old type.	New type.
Output of transformer in kilowatt-hours	573·0	573·0	573·0	573·0
Loss in kilowatt-hours ...	103·5	54·7	55·4	38·2
All day efficiency	84·7%	91·25%	91·2%	93·7%
SUMMER.				
Output of transformer in kilowatt-hours	186·0	186·0	186·0	186·0
Loss in kilowatt-hours ...	96·6	36·3	48·6	20·7
All day efficiency	65·8%	83·8%	79·2%	90·0%

THE PROBLEMS OF COMMERCIAL ELECTROLYSIS.*

BY J. SWINBURNE.

(Concluded from page 369.)

Electro-Metallurgy of Copper.

Electrolysis may be employed either in connection with the extraction of the copper from its ores, or in refining copper, especially when there is silver alone, or with gold in addition, to be extracted.

In the first case—that of extraction of copper from pyrites—the ore may be converted into matt, and the matt can be cast into anodes, or the ore may be acted on by oxidising solutions produced by electrolysis, or the two processes may be combined.

In the first method the matt is cast into anodes, which are treated in baths of copper sulphate with copper cathodes. The sulphides are attacked, sulphate of copper is formed, sulphur and impurities being left on the anode. The copper is deposited, and iron remains in solution. The chief difficulties in connection with this process are that the anodes are brittle and troublesome, and are often eaten away unevenly, and the solution becomes richer and richer in iron salts. In addition to this, it is stated that the circulation of the iron salts must be avoided, otherwise ferric sulphate will be produced at the anode and reduced at the cathode; and this process will go on wasting power over resistance. Some sort of diaphragm is therefore necessary.

It must be pointed out that sulphuric acid can be made from the sulphur dioxide given off in the first roasting of the ores, or from the surplus ferrous sulphate. The ore can be roasted so as to have a good deal of soluble oxide of copper, which can be dissolved in the acid and treated electrically. Merely working with anodes is an incomplete process; it is better to combine it with extraction by lixiviation. The solution, after being in contact with the anode, so as to contain ferric sulphate, is led to the ore. The ferric sulphate is reduced, and the copper and iron are said to be dissolved, and if there is oxide of copper it is taken up by sulphuric acid. This solution is led to the cathodes, where the copper is thrown down, and is then passed to the anodes, where the iron salt is oxidised. The various impurities and the precious metals are left with the sulphur of the anode. The sulphur is burned into sulphur dioxide, which goes to the chamber, and the silver, with the gold, if there is any, is extracted. The sulphate of iron can be burned into sulphur dioxide, and the iron oxide sold as Venetian red. This is, in rough outline, the Marchese process. It may seem strange to those unacquainted with industrial chemistry that if you want to extract copper you should also become involved in making sulphuric acid and red paint; but in chemical works by-products must be utilised, so that often making one thing involves the production of a number of other substances which have, at first sight, nothing to do with it. Messrs. Siemens and Halske avoid the necessity of making anodes of matt by employing carbon. The ferrous sulphate is thus oxidised into the ferric salt, and this is used to lixiviate the crushed and roasted ore. The solution is then led to the cathodes first to take out the copper, then to the anode to oxidise it, and so on.

In the Höpfner process chloride of copper is used instead of sulphate. The action is stated to be as follows:—Cupric chloride is formed at the anodes; this is led to the matt, where it attacks the copper sulphide, forming cuprous chloride and sulphur; and it is also said to dissolve the silver as well as the copper, which, if possible, would be a drawback. I do not know why the chloride

* This Paper will be discussed at the Institution of Electrical Engineers at one of the first meetings after the recess.

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should be preferred to the sulphate; and no information is given as to what is done with the sulphur in the ore, and with the excess of ferrous chloride that must be produced.

The Marchese and Siemens and Halske processes are in commercial operation, and the electric extraction of copper is already a growing industry. The electromotive force necessary for this process is less than a volt; so that, assuming coal to be used, as in the estimate at the beginning of this Paper, the electrical cost is 14s. 5d. per ton for the extraction of copper. I cannot give the whole cost, as that involves so many considerations. This figure will give copper smelters some idea of the saving of replacing the ordinary refining process by electrolysis.

In dealing with such a valuable substance as copper the time element must not be neglected. The interest on the money locked up in the copper under treatment may be a very serious item. This is an objection of some weight in the case of matt anodes, which take some time to dissolve. The whole of the copper turned out is not obtained from the anodes; but, taken all round, it may not be far wrong to assume that the copper takes about three months to pass through the works where matt anodes are employed. If the output is, say, 1,000 tons a month, the copper represents a capital of some £150,000, and the interest increases the cost of refining some 12s. a ton.

Electrolysis may also be employed for refining crude copper. In this case the process is simplicity itself. The crude copper is made into anodes, and thin plates of fine copper are used as cathodes, the electrolyte being sulphate of copper. Pure copper is deposited on the cathodes, and the impurities, and the silver and gold, are left in the mud, and the precious metals are extracted in the ordinary way. It is usual to employ cast anodes, and arrange the plates in each vat in parallel, the vats themselves being coupled in series. This arrangement is clumsy, and should be modified. I have had an opportunity of examining the large copper refinery at the Bridgeport Copper Works, and it may be well to describe the arrangement employed there. As the books were examined by Mr. J. H. Hays at the same time, I am also able to give you the actual cost of the process, without having too roseate a hue imparted by an enthusiastic inventor. The refinery is arranged and worked in accordance with the patents of Mr. E. S. Hayden. The departures from ordinary practice are made with the view of reducing the amount of copper under treatment, and of keeping down the cost of labour.

The anodes, instead of being thick cast copper, are sheets of thin rolled metal. The cost of rolling is small, and the plates used can thus be made thin, and dissolved very uniformly. Each vat contains a number of plates arranged vertically and across the vat. At one end a thin plate is supplied as a cathode. The first plate is made the anode, and copper is eaten off one side of each plate, and deposited on the plate next to it. The result is that each vat acts as a number of small vats arranged in series, and requires only two electrical connections. The whole question of large leads and connections is thus solved. There is almost no waste through partly consumed anodes, as the whole plate is eaten away evenly. The process is carried on until the whole of the anodes are eaten, and their place taken by the pure deposited copper. The plates are hosed and removed, and the slime is treated to recover the silver and gold. The product is the highest grade of copper in the market, and fetches £6. 10s. a ton above "tough cake," or £4. 10s. above "best selected." Silver and gold are completely separated without loss, and as 35oz. of silver and ½oz. gold per ton are allowed as tare, any copper containing more than that yields £8 per ton in bullion. Argentiferous copper thus yields at least £14. 10s., leaving the gross profit of £12. 10s. at present rates. I have here taken the cost of refining at £2 per ton. The actual cost of refining copper depends on the output of the works and the cost of labour. In Bridgeport it came out just over £2 a ton. With modern dynamos, and reasonably good engines and labour at English prices, the cost would be a good deal less, say 20s. per ton. The use of thin plates as anodes also reduces the capital investment in copper, which, as already pointed out, may be enormous, and thus lessens the margin to be allowed for fixed charges.

The Elmore process is too well known to require a full description. The copper is deposited on a revolving mandrel and burnished by a travelling agate burnisher. By this means copper tubes of great strength are made, and by cutting the tubes sheets are produced. Narrow strips can also be made, and these can be drawn down into high-grade copper wire. A number of thin sheets can be made by depositing several separate coatings one over the other on the mandrel. The sheets separate when the tube is slit lengthways.

Writers of books on political economy are fond of saying that the chaffering of the market makes people manufacture in the cheapest way, and that the cheapest and best goods displace dearer and inferior qualities. They forget the interference of custom, ignorance, and prejudice. If a new process is brought out, it takes ages before it is taken up abroad, and still longer before Englishmen will touch it. Here we have a process of refining copper at a gross cost of £1 or £2 a ton, with a gross profit of £13 or so; and yet copper refiners continue their barbarous methods. The first manufacturers to take up copper refining by electrolysis on really modern principles have a chance of making fortunes before the market is disturbed.

Antimony.

Little has been done in the way of treating antimony ores electrolytically. Dr. W. Borchers proposes to use the solution of sulphide in sodium sulphide as an electrolyte, and to deal with the ores. The specimens of antimony ore that I have examined have been perfect insulators, so that regulus of antimony cannot be used as an anode. There will be an accumulation of sulphur in the bath, and it will probably insulate the anode. It is also difficult to say what material could be employed as anode in such a solution. Carbon would be attacked, and platinum would be too expensive, and other metals would be converted into sulphides. As the reduction of antimony by iron, for example, is comparatively easy, there does not seem to be much opening for the electrolytic treatment in dealing with its ores.

Recovery of Tin from Scrap Tin.

This, of course, can be readily effected by electrolysis. The scraps can be made the anode in an alkaline solution, in which iron is not attacked. Though such a method removes all the tin from the surface, it may leave some alloyed with the iron, as no doubt some tin sinks into the iron during dipping.

Electrolysis has also been employed to assist in cleaning plates before dipping. I do not see how it can be of much service here, however. I have examined one of the processes, and it was said to be working very successfully, but I found the brushes had been accidentally left off the commutator.

Electrical Tanning.

Electrical tanning, though it depends on electrolysis, differs materially from all the processes already described in not depending on the isolation of radicles at the electrodes. Ordinary tanning is a very slow process, because it takes a long time for the tannin to diffuse into leather properly. If this substance is an electrolyte, it has a very complex molecule, and therefore diffuses very slowly. The outside of a thick piece of leather also becomes tanned, and to some extent protects the rest from the diffusion of more tannin We may get an idea of what I suggest is the action in electrical tanning by regarding a hide as being made up of cells in groups, with interstices among the groups. If the skin is merely left in tan liquor, it takes months for the liquor to penetrate even into the interstices. It has then to diffuse through the walls of the cells. This is necessarily a very slow process, when it is remembered that the gelatine uses up the tannin as it comes in. Mechanical agitation has been tried, but it does not accelerate the process much. It is probable that agitation helps the liquor into the interstices, but of course it cannot help it into the insides of the cells, or, in fact, into those parts of the leather which are accessible by diffusion alone. The agitation can thus only perform the first part of the process—that is, getting the liquor into the pores that are open to it.

Passing electricity through the vats without agitation has also been tried, but it, again, is of little or no use by itself.

If, however, the skins are agitated and electricity is passed through the bath at the same time, the agitation circulates the liquid into the interstices, and the electric current sends the tannin through the walls of the cells, so that the leather is made infinitely faster than by the ordinary methods. Dr. Rideal and Mr. Trotter have made numerous and elaborate experiments on electrical tanning. The results of their work are given in the exhaustive Paper read before the Society of Chemical Industry. I brought forward this as being probably the explanation during the discussion on their Paper, and it agrees entirely with the results they obtained. The best results, according to this theory, would be secured by agitating the hides first to get the liquor into all the interstices uniformly, and then electrolysing to get the tannin into the skin itself; then agitating to refresh the solution in the pores, and then electrolysing, and so on. Messrs. Rideal and Trotter showed that this method does, in practice, give the best results. Leather made in this way also has a better chance of being uniform, because the outside is not acted on perceptibly quicker than the inside.

Tanning by agitation and electrolysis combined seems to have been invented by Messrs. Worms and Balé, and their process has been worked successfully for some time past in France, and in England by the British Tanning Company. Mr. Groth has developed a modification, and is also making leather by this process. Groth's appears rather better than ordinary leather, being more uniform in texture, and giving better results when tested for tensile strength. It was shown at the Crystal Palace Exhibition this year.

Ozone.

Now that induction coils in the shape of transformers have become commercial, there is every reason to expect that ozone will

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be made industrially. Mr. Fahrig has already been making ozone commercially in this country. He employs an alternate current which works a transformer which gives a high electromotive force. Air is first drawn through an apparatus which is supposed to separate the nitrogen by diffusion. As nitrogen and oxygen have nearly the same densities, it is hardly likely that much nitrogen is separated. The air is then led through the ozonisers. These consist of piles of corrugated metal plates with sheets of celluloid between them. They are alternately positive and negative, being connected to the high-pressure side of the transformer. There is thus an alternating discharge from the corrugated electrodes to the celluloid sheets, so that the air is ozonised on passing through.

Messrs. Siemens and Halske employ ozonisers of the more usual form. Two concentric glass tubes are used. One electrode is inside the inner, and the other is outside the outer tube. High-pressure transformers are of course employed, and the air, or oxygen, is partly converted into ozone on its way there. Very little is known about the electrolysis of gases, if such an expression is admissible. The so-called silent discharge seems to work best, but the whole subject now demands quantitive investigation. The use of glass must involve low efficiency, as glass possesses the property of dielectric hysteresis in a high degree. We also want to know the current-density and freqnency which give the best results. The arc, and, in fact, many forms of electric discharge, produce traces of nitrogen compounds. It is worth pointing out that if under any commercial conditions nitrogen compounds can be produced from air, there would be an unlimited demand. A works situated on a waterfall would have its power and material provided, and the only cost of production would be the interest on plant, and the wages of a man or two to look after the dynamos.

It has been said that chlorine acted on by the electric discharge is affected in the same way as oxygen. In the first place, chlorine is already quite a strong enough oxidant; and in the second, it is difficult to see how chlorine can form an allotropic modification.

Miscellaneous Processes.

Under this head I have classed a few electrolytic processes whose theory is obscure, and about whose practical success there may be some doubt.

Mr. Webster has brought out an electrolytic sewage process. The effluent has electricity passed through it, and this is said to separate the solid material completely, and to kill all germs. Of course, when any sewage containing salt is electrolysed it produces chlorine or hypochlorites, and these would act on organic matter. Hermite, for instance, has applied his process to the disinfection of ships. This does not seem to be the basis of Webster's process, however, and there seems uncertainty as to what the action is supposed to be, and why the solid particles should be influenced by the current.

The next process is ageing wine and spirits by means of the electric current. Whether there is really anything in this I do not know. Various inventors have brought out methods of ageing liquors by electrolysis. There is uncertainty as to whether the result is produced, and as to how it is produced. Various deleterious alcohols might be oxidised into ethers; but it is strange that electricity should select just those that give a taste which is unpleasant to the human palate. Mr. Turell uses a direct, while M. de Meritens employs an alternating, current.

The sterilisation of milk by electrolysis is another process which is somewhat obscure.

The Electric Furnace.

The idea of using the heat of the arc for producing high temperatures for such purposes as melting iridium is about half a century old. Recently, however, we have had the Cowles furnace, used especially for the reduction of alumina. Properly speaking, this does not come within the scope of this Paper, as there is no reason to suppose that electrolysis has anything to do with the reduction of the oxide. By pouring the power from a large dynamo into a carbon resistance, closed in so that the heat cannot readily escape, a very high temperature is produced. Alumina is then reduced by the hot carbon. It may be taken that at lower temperatures, such as those produced by ordinary furnaces, the affinity of aluminium for oxygen is greater than that of carbon, and that at the higher temperature the reverse is the case. It is not impossible, however, that the carbon in an ordinary furnace is inactive merely because it cannot get into good contact with solid alumina, and that in the Cowles furnace the alumina melts. In any case, there is no reason to suppose there is any electrolytic action going on.

The Cowles furnace is applicable to all processes which demand very high temperatures, such as the reduction of oxides of aluminium, magnesium, calcium, barium, strontium, silicon, chromium, boron, tungsten, and manganese. Of course many of these metals are not at present in demand; but then, it must be remembered, that may be because there has, until now, been no way of making them reasonably cheap. Many, if not all, of these metals have been already obtained by the Cowles process.

It is a question of economy whether the Cowles furnace should not be employed in many other reduction processes which do not require such high temperatures. The furnace is efficient, as the heat is applied where it is wanted, and little is wasted by radiation or convection. We thus have to compare an ordinary furnace in which the heat is applied badly, and a great deal is wasted because the gases go off at a very high temperature, with a system which begins with an efficient furnace working a very inefficient heat engine and an efficient electrical machine. The electrical furnace will doubtless soon be applied in many cases, especially those which ordinarily involve inefficient furnaces, and retorts which break down quickly or leak.

The manufacture of phosphorus is a good example. On paper the process is simple. Bone ash, or tricalcic phosphate, is not reduced by carbon at ordinary furnace temperatures, so it is treated with sulphuric acid, and converted into monocalcic, or superphosphate. Making this involves making sulphuric acid, or buying it. Acid phosphate is then heated in retorts with carbon, and two-thirds of the phosphorus is obtainable theoretically. If sand is used it acts as a strong acid—or, rather, anhydride—at high temperatures, and all the phosphorus should be obtainable. The retorts, of course, give rise to trouble and expense. Messrs. Readman, Parker, and Robinson, by employing the electric furnace, can deal with mineral phosphates, and require no sulphuric acid. I do not know whether carbon at the temperature attained in the electric furnace will reduce calcium phosphate to calcium and phosphorus, or whether calcium phosphide is formed. With sand, of course, calcium silicate is formed. One might expect that this would be reduced to calcium and silicon, in which case it would be reasonable to suppose that the operation cou'd be carried on without silica. It has been said that some oxides which can be reduced by very hot carbon when dealt with separately, can form compounds that cannot be reduced if one oxide is strongly acid in comparison with the other. If that is the case, though the lime and silica might be reducible separately, the combination of the two, calcium silicate, might be irreducible. Whether calcium silicate is reducible or not, silica must, of course, be employed if the phosphate would otherwise be converted into phosphide.

It would be well to see what other reduction processes could be dealt with economically by the Cowles furnace. Doubtless there are many, and Messrs. Parker and Robinson are sure to explore the field pretty thoroughly.

Conclusion.

A very few of the possible applications of electrolysis have been described in the foregoing Paper, and the labours of many workers have been passed without mention. This was unavoidable. There is also another difficulty in writing such a Paper as this: I have not worked at all the processes myself, and have had to rely on published accounts in many cases. Out of every hundred new inventions in electro-metallurgy, ninety are impossible chemically or electrically. If I have ruthlessly cut out a possible or admitted an impossible process, I must ask pardon on account of the impossibility of trying all the processes myself, even experimentally, and must plead that I have been as sceptical as possible.

There are other directions in which electrolysis may play an important part. The improvement of the manufacture of white lead deserves the most careful attention. The Dutch process is unhealthy, costly, and barbarous. The electrolytic manufacture of analine dyes has received considerable attention. Dr. Goppelsroeder has done a good deal of work in this direction, and samples of silks dyed by electrolytically prepared colours were shown both in the Paris and Frankfort Electrical Exhibitions. The extraction of gold from sea water, which is said to contain minute quantities, need hardly be treated seriously. Even if it were possible, such a process would be of no use. All improved processes for obtaining precious metals merely enrich some at the expense of others, and reduce the value of the metals. Obtaining gold more easily would be no good to the community unless it became cheap enough to be used commercially.

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"Electricity: its Theory, Sources, and Applications." By John T. Sprague. Third edition. (Thoroughly revised and extended.) (London: E. and F. N. Spon.)

"The Electrical Engineer's Pocket Book." By H. R. Kempe. Second edition. Thoroughly revised with additions. (London: Crosby Lockwood and Son.)

"Chemical Theory for Beginners." By Leonard Dobbin, Ph.D., and James Walker, D. Sc. (London: Macmillian and Co.) Price 2s. 6d.

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THE LANE FOX APPEAL.

Not content with having established beyond doubt, in the case which was tried in March last by Mr. Justice A. L. SMITH, that he was one of the pioneers of electric lighting, if not the veritable discoverer of the principle of parallel distribution at constant pressure, Mr. LANE FOX has endeavoured to get this view confirmed by the Court of Appeal, and took the opportunity of urging the corollary which the Chancery Judge failed to appreciate, namely, that he was entitled to royalties from all those who use secondary batteries in conjunction with dynamos for running glow lamps. And now, after some five weeks' deliberation, the Court of Appeal has confirmed byth the legal decision and the pious opinion of the Court below. Mr. LANE FOX, says Lord Justice LINDLEY, undoubtedly made a great step in advance; he was a pioneer, and showed the road to be followed, but he did not give the traveller the information necessary to enable him to travel on it; and, in consequence, Mr. LANE FOX was not considered legally entitled to levy royalties from those to whom he showed the way in this insufficient manner.

In our comments upon the judgment of Mr. Justice A. L. SMITH we observed that the trial had not shaken Mr. LANE FOX's claim to the discovery of the practicability of parallel distribution at constant pressure, but that, on the contrary, it had established his position on surer ground, and in spite of rather unworthy efforts (which were repeated during the appeal, but with no very great success), to show, or rather to assert, that Mr. LANE FOX had exercised no invention, but had taken well-known things, and had merely attempted, and that unsuccessfully, to accomplish something which would not in

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any event have been of any use. These very assertions elicited from Lord Justice KAY the very clear and just dictum that the man who first applied secondary batteries to dynamos and lamps was a great inventor. We have always held that the attempts to detract from Mr. LANE FOX'S reputation as the enunciator of the principle of parallel distribution for incandescent lighting have failed. But we admit at once, as we have done on a former occasion in this connection, that a principle cannot be patented; and the question for the Appeal Court was, as it had been for the Court below, "Is the patent No. 3,988 of 1878, as twice amended, valid?" Judgment has now gone against Mr. LANE FOX in both Courts on the ground of disconformity. Regulation and a regulator were features of the patent; and the point at issue was whether the regulator could be abandoned, and the regulation tacked on as an inherent property of something else? to wit, a secondary battery which was left in the amended specification. On this head the judgment, which we give in another column, states most unequivocally that no such intermutation can be allowed.

The second point in Mr. Justice A. L. SMITH'S judgment was that the system described in the specification was impracticable, and that an intelligent workman could not successfully carry out the invention without experiment and further invention. It is idle to argue, as was done in both the trial and the appeal, that the description was incomplete. What patent specification seems to be complete when it is a dozen years old? Common sense is not all that is to be applied to a patent case; but according to our system of law the decisions in previous cases are the main guide. Take one, for example. EDISON *v.* HOLLAND was decided by the kneading of a mess of tar putty, which was rolled out into a filament; not by the instructions in the patent, but by the marvellous ingenuity and perseverance of highly-skilled experts. And after this had been done, lamps were made, which glimmered for two to sixty hours; and this was held, not by the Judge in the first instance, but by the Court of Appeal, to be a "practicable process." It is time, therefore, that laymen should prepare themselves to look at patents through legal glasses. Then, as to this everlasting intelligent workman. True, he is the man of the hour; he dictates our laws, and is ready to do anything but pay taxes and work. He, too, is the arbiter of the practicability of patent specifications. Patent a corkscrew, and you must so describe its construction that the intelligent workman may, if he be so inclined, fashion one by the light of the information supplied. But the LANE FOX patent is really for the planning and laying out, and for the designing and the construction of a central station and a network of mains. Is our intelligent workman to do all this? We have followed the evidence and argument in both trial and appeal with considerable attention, and are still of opinion that so far as the battery is concerned, there seems to be no reason why a set of large simple inexpensive accumulators of the Planté type with ample conducting surface, that is area of plate, and not overburdened with active material, should not work very serviceably between, say, 4 to 5 volts up and down. In our comments on the trial in the Court of Chancery, we said that the weakest point in the plaintiff's case seemed to have been the liability of secondary batteries to sulphation unless occasionally charged up to 2·5 volts per cell, and we thought that the necessity for their thorough charging ought to have been frankly admitted. But since that date we have heard more of the much despised Planté. The great discovery of Mr. DRAKE was applicable primarily to pasted cells, and to a less degree to thoroughly well-formed Plantés, formed in fact for real storage purposes. But the simple Planté has a much more hardy constitution, and sound evidence to this effect could, we believe, have been brought forward by Mr. LANE FOX. Ordinary Planté cells would have been valuable adjuncts to the engines and dynamos not only of 1878 but of 1885. That they would hardly be worth having to-day is another matter. But the Appeal Judges here again concur with Mr. Justice A. L. SMITH. Without the ingenious switches and dodges added since 1878, they hold that it would have been altogether out of the question to have applied Planté batteries to a central station network.

The appeal was usually interesting, and at times amusing. Mr. LANE FOX was assisted by his solicitor, and for the greater part of the case by a single expert; while the opposing counsel was supported by one or two barristers, an invaluable expert continually at his elbow, and sometimes half-a-dozen others who looked in to see how the case was going. Lord Justice KAY, from the very first half-hour, took a leading part, feeling, no doubt, that he had not gone through EDISON *v.* HOLLAND for nothing, and being less alarmed, perhaps, than the learned Judge before whom this tangle was first unfolded, he took a broader view of such questions as the alleged difference between regulating and keeping the pressure constant. One of the first remarkable points in the case was the curious extract from Mr. KING'S evidence, which was quoted in Mr. Justice A. L. SMITH'S judgment. Extorted as it was under severe cross-examination about an exceedingly complicated experiment which appeared to have very little to do with Mr. LANE FOX'S invention, and which the counsel certainly failed to understand, the assertion that there would be more variation in the mains *with* batteries than without them was one which required a good deal of explanation, and was, we think, quoted by Mr. Justice A. L. SMITH quite apart from its very involved context. Although Mr. LANE FOX'S view that it was a deliberate misstatement of fact was too strong, it was one of those assertions which the scientific witness, alas, too often makes. Not without reason Mr. LANE FOX declined to take the so-called Ayrton curve as a basis of argument; and no better reason could he have brought forward than the one which he gave in the closing words of his reply. The fact did not transpire during the trial on the appeal that the charge and discharge curve of a pure Planté is altogether different from that of a pasted plate, or even, probably, from that of a heavily-formed lead plate such as the Crompton-Howell; and further, that the "plateau" is flatter, and therefore much more favourable to Mr. LANE FOX'S contentions. A point on which we have to differ with Mr. LANE FOX is his analogy of the compression of gas into an iron bottle. When he first introduced this it was, perhaps, legitimately used; but he brought it up on two subsequent occasions during the appeal to attempt to show that, as a bottle of gas can always be made to hold more if the pressure be increased, so a secondary battery can never be said to be full—a most misleading idea. The distinction which Mr. LANE FOX drew between large conducting surface and large active surface was important; but he was not really entitled to introduce it, as it was fresh evidence, and Mr. WALLACE was fully justified in rejecting it on these grounds, as he did when opening his reply, together with the other new and rather weak argument that 110-volt lamps might be used if it were necessary to go to 110 volts in charging.

In the end, if the plaintiff has suffered in pocket, he has at any rate vindicated his reputation as an electrical engineering pioneer. The Court of Appeal, in common with nine-tenths of our present-day electricians, may not, perhaps, have made sufficient distinction between the

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modern and the plain Planté storage cell, and their notion as to the amount of information which should be given in a patent specification may seem rather excessive; but that there was a decided disconformity between the provisional and final specifications there can be but little doubt, and this alone settled the question of validity. The situation is, we think, succinctly summed up by Lord Justice LINDLEY. "An invention," he remarks, "may be useful as indicating the direction in which further progress is to be expected, and yet that same invention may be useless for any other purpose, useless, that is, as an invention, without further developments which have not occurred to the patentee."

THE BRITISH ASSOCIATION AT EDINBURGH.

THURSDAY.

The proceedings of Section A were opened on Thursday last week in Edinburgh by a most interesting and suggestive address by Prof. Schuster, an abstract of which will be found in another column. Not a few members missed the pleasure of hearing it through one of those careless blunders of organisation which detract so largely from the usefulness of the Association. It was announced on the general programme that the Sectional Meetings would begin at 11 o'clock; but Section A assembled at 10, notice of the change having been made on a board in a remote corner of the Parliament Hall, which was arranged as a reception room. About a hundred and fifty members were present in Prof. Tait's lecture room. The remainder of the day was spent on sundry reports on meteorological and kindred matters, several Papers announced on the programme being postponed.

In Section G, Prof. Unwin delivered an address, of which we also print an abstract this week. This was followed by a Paper on the Chicago Exhibition, after which Prof. Forbes gave a sketch of his scheme for the electric lighting of Edinburgh. This was the only Electrical Paper in this Section on Thursday.

FRIDAY.

Prof. H. E. J. G. du Bois, in Section A, read a Paper on "Magnetic Circuits," dealing with effects of leakage. Dr. Dawson Turner followed with an experiment which failed to "come off," but which was arranged afterwards in an adjoining room. He showed that the resistance of a heterogeneous or discontinuous conductor, such as metallic powder, was affected by a neighbouring disruptive discharge; but offered no theory beyond the suggestion that there was an "orientation" of the molecules. The discussion failed to elicit anything worthy to be called an explanation, and no one having anything to say about it, Prof. Forbes made some remarks on the behaviour of sulphide of silver. That this had little to do with the subject of the Paper was of small consequence at a British Association meeting; anything will do as long as it is interesting.

Prof. E. Wiedemann described some experiments of the Hertz Tesla order. He spoke excellent English, hardly once being in a difficulty for a word. He happened to use the expression "evacuated" instead of the more common "exhausted" in connection with vacuum tubes, and the word being adopted afterwards in discussion by Dr. J. T. Bottomley, it was afterwards used by Prof. von Helmholtz and others. Some of the audience had a little difficulty in understanding the meaning of "glim licht" and "dark rooms" in the vacuum tubes. The "glim licht" was obvious, and the "rooms" were "spaces." The speaker vainly endeavoured to depict these on a blackboard, with greasy and perfectly unsuitable coloured crayons which had been provided instead of coloured chalks. The exact arrangement of the tubes and inductors was rather difficult to follow, but an important point in the communication was the distinction which was drawn between conduction and absorption. When a tube fails to glow it is sometimes said to be due to non-conductivity, but Prof. Wiedemann pointed out that since the light was due to absorption of the radiation, it should more properly be said to be due to non-absorption.

Dr. J. T. Bottomley, who has used vacuum tubes without electrodes long prior to Mr. Tesla's brilliant demonstration, described experiments with a form of vacuum tube which he showed at a *conversazione* of the Royal Society more than a year ago. The connection between the pushing of an electrode into the internal tube and the experiments of Prof. Wiedemann appear to consist merely of the extinction of the light in each case.

Prof. Schuster gave a clear sketch of investigations which he had made upon the conductivity which exists in a vacuum tube during a discharge through it, and the electrolytic phenomena and polarisation which accompany the passage of a current through subsidiary electrodes in such a tube.

Prof. Crookes' remarks, which followed, appeared to refer to Prof. Wiedemann's experiments rather than those of Prof. Schuster. He had nothing to say about polarisation, but something about the non-luminous condition of vacuum tubes without electrodes. The fact that such tubes assume a passive state is interesting, but no explanation was forthcoming. Dr. Dawson Turner had used the expression "orientation" in connection with the passive state of his metal powders, though hardly intending that it afforded any explanation; but Prof. Crookes on making a suggestion about the vacuum tubes, used another five-syllabled word—dissociation—to "account for" the phenomena. Some phenomena might be "accounted for" to some audiences by the use of a single well-chosen six or seven syllabled word. But one must not grumble at lack of completeness or method in connection with Sectional Meeetings of the British Association; and no one who was present could possibly have felt that the privilege of seeing and hearing Prof. von Helmholtz was lessened by the fact that the discursive nature of the discussion was extended by his remarks, which had nothing more in common with the business of the meeting than that they at first related to a vacuum tube, and as this one contained mercury, to other tubes containing mercury. Had he continued to discuss the properties of mercury even without glass tubes at all, no one could have resented it. Before Prof. von Helmholtz rose, however, two other foreign members made a few remarks. The name of one neither the secretaries nor chairman made any endeavour to divulge; the other was Prof. Arrhenius, who was well received by the meeting as one of those distinguished foreign visitors whom to see and hear is an attraction which no mismanagement can spoil,

Prof. von Helmholtz, was, if we may be allowed to say so, one of the principal attractions at the meetings of Section A. With an excellent command of English idiom and pronunciation, he made a few introductory remarks about electrolysis; he passed to the adherent stratum of air in vacuum tubes, and then to an extremely interesting explanation of certain effects by the contact difference between glass and mercury. Returning to the air stratum he surprised many of the audience with the fact that this, though not exceeding $\frac{1}{2000}$ of a wave length of light in thickness, was sufficient to introduce an error in the use of a column of mercury as a standard of resistance.

Lord Kelvin commented on Prof. von Helmholtz's remarks on contact potential of glass and mercury, and drew attention to the resuscitation of the older experiments, which have been neither interpreted or appreciated. We alluded only a short time ago to the return to electrostatics; and this revival has now reached a point at which, when prime conductors are again mentioned, it seems unwise to speak disrespectfully about the "head of hair."

Lord Kelvin followed with a communication upon a dynamical problem which is beyond our province to dwell upon at length. He has been engaged upon calculations of a most extensive and elaborate nature for about a year, and while he only briefly touched upon the results, he said enough to show that these are of great interest, not only mechanically, but in their application to the kinetic theory of gas and Maxwell's theory of the distribution of energy. As we have not alluded to this Paper in our report of the proceedings, we will give a brief outline of the contents. If a particle is free to roll in a smooth curved trough, it can either be projected in a straight line, rolling along the bottom of the trough, or it may be dropped from the edge, and, running down one side, it will by its momentum run up the other, and, returning, oscillate

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in a plane perpendicular to the length of the trough. If it be projected in a general direction, it will follow a path compounded of these two motions. The motion in the length of the trough is not affected at all by the oscillatory motion, and *vice versâ*. If, however, the trough is not of constant curvature, one part being flatter and another deeper, an exceedingly interesting result follows. The irregularity will give rise to instability, and the particle will oscillate more and more widely and would soon fly over the edge of the trough. The edges might be curved inwards to retain it, or it might be covered in, forming, in fact, a tube. Exactly the same result will take place if, instead of irregular curvature, the tube were rough. There is no limit to the instability of the oscillations, and if enough energy is imparted, the particle may rise to the top of the tube, and may even return. Another arrangement of the problem is a horizontal plane, below which a number of magnets are placed at intervals; an iron ball projected along the plane in a direction slightly inclined to the row of magnets will be diverted by the magnets as it passes them, causing it to oscillate more and more widely. This ball of iron, said Lord Kelvin, would, of course, have no magnetic friction or hysteresis to trouble pure mathematicians. Another form is a succession of convex lenses. If a ray is sent through them it will zigzag through them, and if they are not each closer together than one-quarter of their focal length, it will become unstable and escape. Lord Kelvin, who was in his best form, described the problem in a most graphic manner, and, attended by three trembling assistants armed with sponge, rag, and chalk, covered a blackboard with curves showing the laws of stable and of unstable periodic motion. The board, being arranged in three vertical sliding portions, was shifted by his assistants, one portion at a time, until it was covered with a bewildering diagram of curves interspersed with i's, signifying impossible solutions. So far from having been exhausted by his discourse, Lord Kelvin proceeded to demonstrate some simple cases of the problem by a model consisting of a crank and jigging arrangement from which a small wire pendulum was suspended. The crank being turned, the pendulum soon began to oscillate until it turned completely over and finally smashed. This was replaced by a longer pendulum of string, which, too, was set in oscillation by the vertical motion, the greatest swing being produced when the period of the vertical motion was twice that of the natural period of the pendulum. A faster motion jerked the ball, the force being greater than that of gravity, and had the experiment been continued, the ivory ball would probably have made a disruptive excursion into the middle of an intensely interested audience.

Prof. Osborne Reynolds alluded to experiments at Owens College, Manchester, on the stability of structures and the periodic conditions of a rapidly revolving shaft. Illustrating the problem by the handling of a long pointer, he suggested another problem of periodic stability to Lord Kelvin, who seized the rod and endeavoured to balance it on the tip of his finger, at the same time, giving it a brisk up-and-down motion, saying that this, if properly executed, would impart stability to the rod. Prof. von Helmholtz alluded to the production of waves on the surface of water by means of air currents, and showed by means of curves on the blackboard how, after a certain condition is exceeded, the crest must burst into a breaker.

About 120, and at one time nearly 150, members were present at this very interesting part of the meeting; but the subject of the next Paper, the ever-to-be-discussed and never-ending "Efficiency of Transformers," caused something like a 50 per cent. drop in the attendance. Prof. Ayrton communicated the results of Dr. Sumpner's method of measurement, and Dr. Sumpner gave additional information, illustrating the subject by curves of losses under different conditions.

Prof. Reinold then read a Paper on "The Electrical Conductivity of Thin Films," the audience having now become decimated; and at about 1:30 p.m., before an audience of about 22, Mr. Magnus Maclean discussed some experiments with an Induction Coil; and the meeting was brought to a conclusion by a Paper from Mr. J. Gray on "The Theory of a Perfect Influence Machine."

Simultaneously with the most important Papers in Section A on Friday, a Paper was read by Mr. A. Siemens on "The Electric Locomotives on the City and South London Railway," which will be found in another column. This was followed by a brief discussion, after which a Paper by Messrs. Purdon and Walters on "A Stream Water-motor" was read. The apparatus consists of a number of blades mounted on a chain like the buckets of a dredger, and set in motion by a flowing stream. The authors claimed an efficiency of 25 per cent.; but in the discussion Prof. Unwin pointed out the uselessness of the expression "efficiency" in such a case. It was only a question as to how much horse-power could be got out of it Prof. Blyth then described and exhibited models of windmills for generating electric light to an audience of 30, of whom eight were ladies.

Saturday.

The proceedings in Section A on Saturday commenced with a Paper by Mr. Magnus Maclean on "The Sources of Heat in the Galvanic Battery;" and Dr. Peddie gave an account of measurements of the electric conductivity of bismuth and copper in magnetic fields. Prof. Michelson described a new method of spectroscopy of considerable importance; and Mr. A. A. Campbell Swinton exhibited some enlargements of photographs of electrical discharges and several prints from negatives, on which the spark from an induction coil had produced a direct image. Mr. J. H. Gray described an instrument for drawing electrical oscillations of slow period. The apparatus, which was not very clearly explained, seemed to depend upon the action of an electromagnet excited by the oscillatory current. The curves were traced on smoked paper. Prof. von Helmholtz, whose name was alluded to in connection with the mathematical treatment of this subject, made a few remarks, and thought that the method given in the Paper could hardly be expected to give good results. He described his well-known condenser method with double contacts at known intervals of time.

A Paper on the scientific amusement known as "Inductoscript," by Rev. F. J. Smith, was read, and photographs of impressions of coins made in this way were exhibited. With Lord Kelvin's warning in view we will not disparage this experiment which has recently been brought before the Physical Society. Mr. Swinton's photographs were interesting as indicating distinct differences between positive and negative sparks, and they may some day throw light upon a difficult subject; but "inductoscript" photographs of coins seem to be little else than curiosities. Prof. Smithells showed some very interesting experiments with modifications of the Bunsen flame, which gave rise to a long and animated discussion, in which Lord Kelvin, Prof. von Helmholtz, Sir G. Stokes, and others took part, the chief question being whether the spectra of flames are due to the temperature or to chemical combination. During Prof. Michelson's Paper about 50 members were present, and about 40 remained to the end of the meeting.

Monday.

On Monday a large audience was attracted to Section A to hear the discussion on a "National Physical Laboratory;" but were somewhat disappointed. Lord Kelvin followed with two mathematical Papers. One of these was on the "Reduction of Every Problem of Two Freedoms in Conservative Dynamics to the Drawing of Geodetic Lines on a Surface of given Specific Curvature;" and he explained that the problem of drawing geodetic lines was attacked by every shop assistant who attempted to tie a parcel with string. The string should take a certain route between two points, or it might slip off. He alluded to the universal importance of the method of least action, and then went into a general problem on the motion of bodies with two degrees of freedom, illustrating the matter by swinging a door and rotating a foot-rule supposed to be attached to it. The aiming of a gun was another example of two degrees of freedom, altitude and azimuth, and the mathematical treatment of the problem appeared to prove that one can always hit the target; though the path of the projectile may, indeed, be sometimes imaginary. He described a system of kinetic triangles and admitted that certain mathematical work was the art of making easy things difficult.

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Monday in Section G was supposed to be devoted to Electrical Engineering; but after the presentation of a valuable report on "Graphic Methods" by Prof. Hele Shaw, there were only two short Papers by Mr. Preece on telegraphic matters; a Paper by Mr. Kapp, in which the really interesting points relating to a set of curves are not alluded to; one on "Electrical Locomotion," by Mr. Woods; and the promise, which was not fulfilled, of a Paper on "Coal Cutting by Electric Power."

A discussion on Prof. Hele Shaw's report was allowed, although it is not customary with the British Association to permit any discussion upon reports, and resolutions thereon are altogether out of order. The audiences at the Sectional Meetings are undoubtedly of a very heterogeneous character; and it would be unwise to give a voting power to those who look in to hear a discussion between Lord Kelvin and Prof. von Helmholtz on their way to a discourse on "The Use of Narcotics by the Nicobar Islanders," having been disappointed by the non-appearance of Prof. Garner, who was to have lectured on the language of monkeys, or perhaps having been bored by "Syntheses of Butane and Pentane Tetracarboxylic Ethers." But discussions were permitted on more than one occasion this year; and after Prof. Hele Shaw read parts of the abstract of the report on "Graphic Methods," and had given a few examples of their use, one speaker urged the committee to further encourage this branch of mathematics by the issue of the further report which was suggested by Prof. Hele Shaw, and complained that there was apathy, if not prejudice, among many mathematicians against graphic methods. He said that Germany was far ahead in this, and that some graphical methods used in Germany are as unknown to English engineers as differential calculus is to the Fiji islanders. Another speaker thought that if the report could be extended, publication should be deferred for another year. A third speaker ventured to propose a resolution, but was informed that this could not be done. Prof. Osborne Reynolds thought that graphical methods were often too complicated, and he preferred to make use of better known processes. The president, in closing the discussion, to which Prof. Hele Shaw had no opportunity to reply, said that Prof. Henrici had probably done as much for graphics as any German writer.

Tuesday.

On Tuesday several reports were taken, and Prof. Ewing exhibited and described his magnetic curve tracer, of which an account will be found in another column. A short discussion, of which we hope to give a brief report, followed. Prof. Du Bois showed a magnetic balance, and made one or two measurements to demonstrate its action. This instrument, which was exhibited in a somewhat less complete form at Frankfort, has been described briefly in our columns (*The Electrician*, Vol. XXVII., p. 634). One ingenious detail was received with applause. The length of the test bars is 122 mm., thus cancelling out the ubiquitous 4π.

After this the report of the Committee on Electrical Standards, for which we hope to find space in a future issue, was read in abstract by Mr. Glazebrook, and was followed by a brief discussion, opened by Prof. von Helmholtz. The programme was about three-quarters of an hour behind time, and was further delayed by two rather long but valuable communications from Dr. Lindeck and Dr. Kahle on "Resistance Coils" and "Clark Cells."

Many prominent members had left the meeting, which generally thinned down soon after 1 o'clock from natural causes; but as the discussion on the "Nomenclature of Units" had been adjourned for two years in succession, Dr. Oliver Lodge declined to give way a third time, and opened the debate by some remarks upon a communication which we hope to print in an early issue. Our correspondent "W. M. M." would have been interested to hear Dr. Lodge reiterate that self-induction *is* a length. The simple but revolutionary suggestion that the micro-farad should be renamed the farad, and that the name weber should be resuscitated for the unit of magnetic flux, were stoutly combated by Dr. J. Hopkinson, who also strongly objected to the word "mo." Mr. Preece contented himself, as far as the last word was concerned, by deprecating the bad habit of dropping the letter h; but while he made no proposition to the meeting, he gave notice that he intended to move at the forthcoming Congress at Chicago that the volt should be increased tenfold. It is to be hoped that if this Congress is held, and if this resolution be brought forward, that Mr. Preece will not attempt to retain the old name for a new unit, but will be sponsor for a new appellation, or, better, have a dozen or two all ready to select from.

Owing to the lateness of the hour, Mr. Preece summarised his Papers on "The Dielectric of Condensers" and on "Earth-currents" in a few words. It appears that condensers as used in telegraphy entail a considerable waste of power, and that records of earth currents, including those which we published last week, are of no use whatever. Mr. Preece's Paper will be found to contain suggestions for the proper description of these phenomena.

Prof. S. P. Thompson gave an account of some recent experiments with arc lamps surrounded by different gases. No difference in the voltage was found, and he concludes that the endothermic flame described by Prof. Crookes cannot therefore be connected with the voltage of the arc. The last Paper of the day by Messrs. Barton and Williams on "The Temperature Variation of the Magnetic Permeability of Magnetite" was dismissed in a few minutes, no discussion having been invited on the last four Papers through want of time.

Nothing of direct electrical interest occurred in Section G on Tuesday, except a description of a gas engine by Mr. Day, which is said to be capable of running at 1,000 revolutions per minute, and able to run at 500 revolutions without missing fire.

Wednesday.

Prof. Barrett opened the proceedings of Section A by giving notice that there was no report by the committee on Recalescence. A method of drawing lines of magnetic force, devised by Rev. F. T. Smith, was described by one of the secretaries. Prof. Knott described and illustrated by experiment some effects of magnetisation on the internal volume of iron and steel tubes of the same external diameter, but of different thicknesses. The results were shown by curves. The abscissæ represented magnetisation, and the ordinates volume. The whole volume was not represented, as the ordinates would have had to be about 62 miles long, but only the differences were shown. The apparent penetration of magnetism into the walls of the tube suggested that the investigation when complete will lead to very interesting results.

Prof. H. E. du Bois exhibited two polarising gratings, the one of platinum, the other of silver wires one twenty-fifth of a millimetre in diameter, and one twenty-fifth of a millimetre apart. He said that since the experiments of Hertz researches had been made which were the piers of a bridge destined to connect the continent of optics with that of electricity, and his experiments were the stones of a new pier of that bridge. The wave length of the "light" used was as great as 400, that is in the invisible ultra-red part of the spectrum, and he hoped to reach 1,000. Beyond this lay the Hertzian vibrations. An interesting discussion ensued, during which it was suggested that a similar experiment might be carried out with Leyden jar oscillations and a screen composed of pillars twenty metres diameter and twenty metres apart.

Prof. G. F. Fitzgerald gave some calculations on the rate of propagation of magnetism in iron, in which he attempted to estimate the velocity of a disturbance in a row of magnets arranged and reacting according to Ewing's theory of the structure of a magnet. He found that slow vibrations would give a short wave length, and not the contrary, as might be imagined.

After Dr. A. Keiller had described some early experiments of Mr. James Lindsay, of Dundee, in 1836, the meeting greeted with applause Dr. John Kerr, whose name is associated with the historical research on the reflection of light from a magnet. He described some experiments on dispersion in carbon disulphide under intense electrostatic stress. Among the last Papers, which were taken at the rate of about one and a-half minutes each, Prof. Ostwald made a few remarks on the general theory of energy and the kinetic explanation of all physical phenomena; and the proceedings were brought to a close by a communication from Dr. Gladstone and Mr. Hibbert, on "Some Notes on the Electromotive Force of a Secondary Battery."

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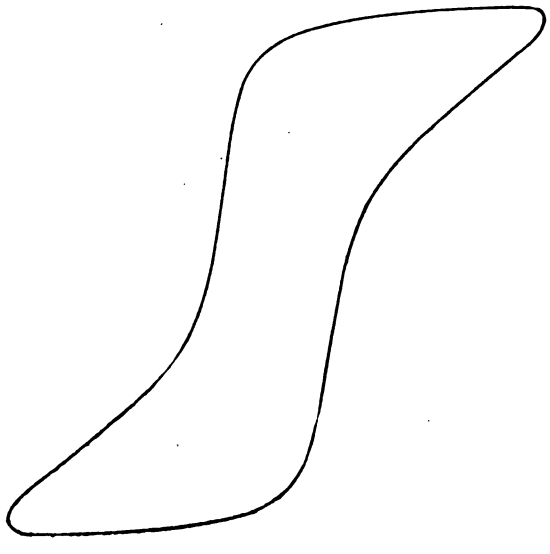
Although not forming part of the Sectional Meetings of the British Association we cannot close this *resumé* of the proceedings without referring to Prof. Ewing's very interesting lecture on Monday evening entitled "Magnetic Induction." The early portion of it covered much the same ground as his discourse before the Royal Institution last year. The projection of the wobbling magnets on the screen produced roars of laughter, as it did on the former occasion. It is difficult to see what there is that is so ludicrous in the magnified shadows of a dozen little magnets; we recommend the subject to psychologists. A modification of these experiments, which was not shown at the Royal Institution, was the motion of the magnets under water, showing the effect of damping the oscillations. Several curves of magnetometer measurements of large groups of magnets were shown; but the *pièce de résistance* was the use of two curve-tracing instruments, by which the well-known hysteresis curve was projected on a screen some 30ft. square.

One of these instruments, of which a description will be found in another column, was used to show the magnetisation of solid iron bars, and a brilliant spot of light traced out the curve on the screen. A second instrument was provided with a bundle of iron wire for a core, and with this the curve could be traced no less than 20 times in a second, the curve appearing continuous. It was noticed that the rheostat which was driven by a motor ran away once or twice, and the curve assumed the shape shown in the sketch, and on several occasions the curve



was contorted into strange loops and waves. These effects are partly due to eddy currents, but appear also to be connected with mechanical inertia, and further experiment will, no doubt, enable these effects to be separated, and there seems to be good reason to hope that the instrument will be capable of running at the ordinary frequency of alternate-current machinery.

A SKETCH OF SOME OF THE ELECTRICAL PAPERS IN SECTION A.

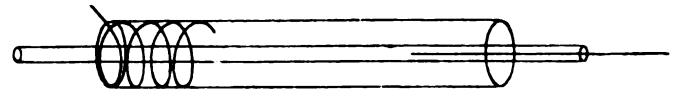
Dr. Dawson Turner exhibited an experiment showing that the passage of sparks between the terminals of an induction coil produced an effect upon a conductor in the neighbourhood of the discharge affecting its electrical resistance. The result was that the resistance was lowered temporarily. Powdered copper and a solid stick of powdered aluminium mixed with powdered resin, and contained in a glass tube, was acted upon in this way. The normal resistance was very high, but when a spark passed in the neighbourhood a couple of cells placed in circuit with it and a galvanometer showed a deflection. On shaking the tube the resistance became higher, and on leaving it at rest for an hour or so the resistance increased to the normal amount. The resin and aluminium could not be restored by shaking; it had to be warmed. There appeared to be an "orientation" of the molecules. Pressure of a mixed powdered conductor of this kind, of course, lowered its resistance; but a spark of an induction coil in the neighbourhood lowered it temporarily and left it in an unstable condition, and a slight jar would cause it to return to a condition of high resistance, while a spark at a great distance lowered it again.

Prof. G. Forbes said that he had repeated Faraday's experiment with sulphide of silver. He had used a 1-centimetre cube of the material. With a cell or two it was practically an insulator; but with 14 volts a sensible current passed, and this soon increased, until, as Faraday had shown, the resistance rapidly diminished, and the substance fused. He asked whether Hertz radiations might not in a similar way break down the resistance, and thus complete the circuit. He inquired how long the powdered conductor took to recover its high resistance.

Dr. Dawson Turner, in reply, said that aluminium powder would recover in about a quarter of an hour, if left without shaking, but a stamp of the foot on the floor or the passing of a cart in the street was sufficient to determine it.

Prof. E. Wiedemann made a communication on electrical discharges. The experiments were made with an ordinary Hertz radiation apparatus, consisting of a generator, a spark gap, a circuit from 5 to 40 metres long, terminating in a pair of plates. Near the plates, vacuum tubes were placed, and the glowing of these was studied. It was found that tubes of large diameter lighted up more readily than smaller ones. Some of the tubes were coated inside with a thin layer of platinum or silver. A second smaller tube was arranged so that it was just beyond the influence of the condenser plates, but as soon as the large tube lighted up, it acted on the small tube, and lit it up as it were with a match: but the effect could not be screened off by a dark sheet. It was requisite in these experiments to use regular and maintained oscillations of a low pitch. For this purpose the long circuit was bridged across by one or more wires, and the nearer these were to the end of the circuit, the better was the result. Under the simplest conditions of discharge the negative end glowed with a blue light, and the positive with a red; but it appeared that in these experiments the negative effects lasted for a certain time, and both ends of the tube appeared blue, while the red was in the middle. Dark spaces were seen near the electrodes, and with lower pressures these dark spaces grew until the whole tube became dark. It appeared that this was due to non-absorption rather than to non-conductivity. Prof. Wiedemann remarked that he had tried a vacuum tube shaped like a parallelopiped, and found that it would light up when placed with the longer dimension placed in the direction of the discharge, and remained dark when turned round at right angles to this position.

Mr. J. T. Bottomley said that absence of light in vacuum tubes at the beginning of a discharge was well recognised, and he asked whether the darkness observed by Prof. Wiedemann was of this kind, or if it were permanent. He had noticed that a vacuum tube, with or without terminals, would sometimes not glow, but on continuing the pumping the light would suddenly start up. The light would generally go on, but sometimes it would stop. He described one method of doing this. He had used vacuum tubes provided with a central tube open at both ends to the air (see fig.). A wire might be inserted into the



ends of the open tubes, or, better, one wire might be inserted at one end, and the other might be coiled with a few turns round the outer tube. By pushing forward the straight wire, the discharge ceased. If the tube in this condition were rubbed against the prime conductor of an electrical machine, the luminous power would be restored.

Lord Kelvin having taken the chair, Prof. Schuster read a Paper "On Primary and Secondary Cells in which the Electrolyte is a Gas." When a discharge passed in a vacuum tube, the whole interior of the tube became a conductor. He had studied the laws of that conduction, which he would call secondary conduction. Wires of different metals had

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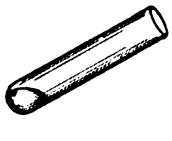
been arranged at different points in the sides of vacuum tubes. No effects of polarisation in these wires had been discovered, although carefully looked for, when these wires were of platinum, and when the tube contained nitrogen, hydrogen, oxygen, water vapour, or cyanogen. There was either no polarisation or only a very small trace. But with hydrocarbons or phosphuretted hydrogen, there were very marked phenomena of polarisation. With rarefied marsh gas for example, the main discharge in the vacuum tube was produced by about one thousand cells, and a steady current from a few cells was sent across the tube. On breaking this current and connecting the wires with a galvanometer or electrometer, a back-electromotive force of 4 or 5 volts was observed. The polarisation fell off after a time, exactly as it does with water, apparently following the same law. The resistance was enormous, and the current was very minute. The results pointed to electrolysis, and depended on the metal of the electrodes. With iron and copper there was hardly any effect, and what there was was independent of the pressure of the gas. With magnesium and aluminium the polarisation increased to an enormous extent. With magnesium, through which currents had been sent for a long time from a single cell, there was a back-electromotive force of 35 volts. A deposit was formed on both electrodes; this was a chemical compound of magnesium and carbon. The deposit was thin enough to show colours like those of oxides; but there was evidently not a mere deposit of carbon, but something of the nature of a chemical combination. Arrhenius had used electrodes of zinc and platinum in air, and had found a difference of potential of about one volt, the same as when the electrodes were immersed in a liquid electrolyte, the zinc was negative to the platinum. He had found magnesium to be the most active. In using nitrogen it should be remarked that nitrogen acts chemically on magnesium. Magnesium gave about one volt with hydrogen, and rather more than one volt with nitrogen. The magnesium was positive to the platinum.

Prof. Crookes said that he had experimented with long tubes containing rarified oxygen, this gas being the most luminous. They were exhausted, and used in the same way that Tesla had done, holding them near the terminals in the hand. If a tube had been lying quiet for some hours in a cool dark place it would remain dark, but if he did something—he did not quite know what—if he touched a terminal of the coil with the tube, or with his hand, the tube would become luminous. A tube would become non-sensitive in about half an hour or three-quarters of an hour. It might be that the gas required to be in a state of dissociation, or some other state in order to become luminous.

After some remarks from a foreign member, whose name was not announced, Prof. Arrhenius made some comments upon the experiments of Prof. Schuster, and said that certain compounds were undoubtedly formed upon the wires, but nothing was yet known about their electrolytic properties.

Prof. von Helmholtz said that he had followed the well-known electrolytic theory of Faraday. This electrical law was based upon the idea that all chemical combinations were composed of at least two atoms, one charged positively, and the other negatively. This was the ordinary hypothesis, but it applied to other cases. On the surface of glass there would be found a little stratum of gas. This gas had molecules which could be separated into positive and negative, and there was the possibility that the positive molecules could be drawn away by a positive charge, and an opposite charge might be induced through the tube. He had experimented with a glass tube containing a

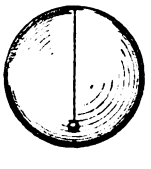


little drop of mercury (*see* figure); the tube was exhausted. When it had been left in repose for some time there was no sign of any electrical charge on it. If the tube were turned so that the mercury ran to the other end the mercury would become negative and the tube positive. There was no other friction than that of the rolling drop of mercury. The contact was more close in the exhausted tube than when a stratum of air adhered to the glass. In the construction of a mercury unit for a resistance standard the separating effect of this stratum had been recognised. The mercury column had a greater resistance, although the thickness of the stratum was quite invisible, and much too thin to show Newton's colours. A thickness of one two-thousandth of a wave-length of light gave sufficient diminution to be detected by a galvanometer. If the tube was exhausted before filling it with mercury, the resistance would be less, because the mercury was in closer contact with the glass. The lowest value of the resistance was obtained when a drop of petroleum was allowed to spread over the internal surface of the tube. Thus it could be proved that there was a measurable stratum of air on the surface of the glass tubes. If the tubes were exhausted the greater part of this went away, but some traces always reappeared.

The so-called electrification of friction was really the same as that of Volta's imperfect idea. He had dealt with the electrical difference of metals, but he did not recognise that non-conductors could exist which acted similarly, and these did not come into his "series of tensions." Some substances behave electrolytically, and if these are used in a battery there can be no equilibrium before the whole is destroyed and decomposed. It was clear that if the mercury moved, the mercury and the glass being electrically different, the glass would be electrified. The only difference was that the electrification could not move, since the glass was a bad conductor. In a voltaic pair the two conducting bodies cannot separate without a discharge, for it is impossible to separate two surfaces all over at once. There is always a last point, and then the discharge will take place. But it is another thing if a glass plate is one of these bodies. It might be considered as an insulator, for not much electrification could be transmitted to the last point. The glass, therefore, became charged.

In frictional electrical machines there was mercury or similar metallic surface, and the glass was electrified one way and the rubber the opposite way. When the glass was separated from the rubber it remained electrified, but the glass was covered with a silken piece, and a conductor conducted new electricity to that place, instead of the electricity which had been carried away. If the tube illustrated above was allowed to repose, all signs of electrification vanished. This was because the glass was not a perfect insulator. With reference to the stratum of air, he had never seen a tube completely freed from gas.

Lord Kelvin said that Prof. von Helmholtz's remarks had reminded him of an electrical night-light which was shown and described by his (Lord Kelvin's) predecessor. It was a vacuum tube containing mercury; when it was shaken it showed a light, and was said to give enough light to show the time by a watch. This was called "electrical," but it was never tested, nor had it been looked at for a long time, and no one from then till now had the slightest idea of the explanation until Prof. von Helmholtz had given it. We now understood it, and saw that there was a great tendency to electrification in the interior of the glass. Dr. Bottomley had experimented with a pendulum oscillating in a vacuum. In a ball of glass a lead ball was suspended by a silk fibre, and it continued to oscillate for 16 hours. But there was so much electricity in the interior that if the ball touched the glass it would stick there. This appeared to be due to electrification by contact.



Dr. Bottomley said that he had observed that a vacuum tube without electrodes would sometimes give no light when first brought into a field, but would suddenly acquire the property by rubbing the outside against an electrified conductor. He

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asked whether Prof. Wiedemann had tried this. Prof. von Helmholtz said that the luminous effect might be seen in every barometer if it were swung. Lord Kelvin asked whether with other metals the tube would be susceptible. Prof. von Helmholtz replied that his assistant, who had been investigating the phenomenon, had only tried mercury, but had mixed it with sodium to form an amalgam, but the amalgam did not flow easily. Lord Kelvin said that now we were beginning to think that we understood some of the old phenomena; these were being brought out, and long-forgotten experiments were being explained and were becoming important.

Prof. Reinold read a Paper by himself and Prof. Rücker on the specific conductivity of thin films. He alluded to the previous Paper on this subject, and described the optical and electrical arrangements of the experiment. Plateau's soap-bubble mixture had been employed, but this was a bad conductor, and an attempt had been made to improve it by adding nitrate of potash. But they now found that films with salts and without salts gave very different results. With a film which there was good reason to suppose had a real thickness of 22·5 micromillimetres, the addition of 0·5 per cent. of KNO_3 gave a result corresponding with 14·5 micromillimetres; with 1 per cent., 13·5; and with 3 per cent., 12·4. The general result was that the specific conductivity of a film appeared to greatly exceed that of the liquid of which it was composed. This might be due to a difference of temperature, or to the absorption of gases, but it was due in some way to the tenuity. In the thinnest films which had been observed the resistance was about seven times greater than in a large mass of the same liquid.

Prof. Rücker said that the surface tension probably disturbed the mechanical equilibrium, and suggested that soap molecules being extremely complex, might be more affected by such mechanical disturbance than those of metallic salts.

ELECTRIC LOCOMOTIVES ON THE CITY AND SOUTH LONDON RAILWAY.*

BY ALEX. SIEMENS.

The object of the present communication is to place on record the performances of two electric locomotives, the most powerful of their kind, which were supplied at the end of last year by Messrs. Siemens Brothers and Co. to the City and South London Electric Railway.

In the year 1888 the Company, then called the City of London and Southwark Subway, issued a specification asking, among other things, for electric locomotives capable of developing a maximum of 100 brake H.P. Owing to financial considerations, the contract was not placed with Messrs. Siemens Brothers and Co., although a perfect agreement had been arrived at on the technical points of the question. The City and South London Company, however, invited Messrs. Siemens Brothers and Co. again in the beginning of last year to tender for locomotives in accordance with a specification practically identical with that agreed upon in 1888; and as a result two electric locomotives have been built, and are now working.

Each locomotive carries two motors, and the use of all gearing is obviated by winding the armatures of the motors on the axles of the wheels of the locomotive. This method of construction was illustrated by a model shown at work at a meeting of the Society of Arts on May 18, 1881, and had been first suggested by Sir William Siemens, who, at the time of his lamented death, was actively preparing a proposition to work the Metropolitan Railway by electric locomotives. The motors for the two locomotives were tested before they were fitted into their places by means of a Prony brake, and some of the results of this first set of tests are given in Table A.

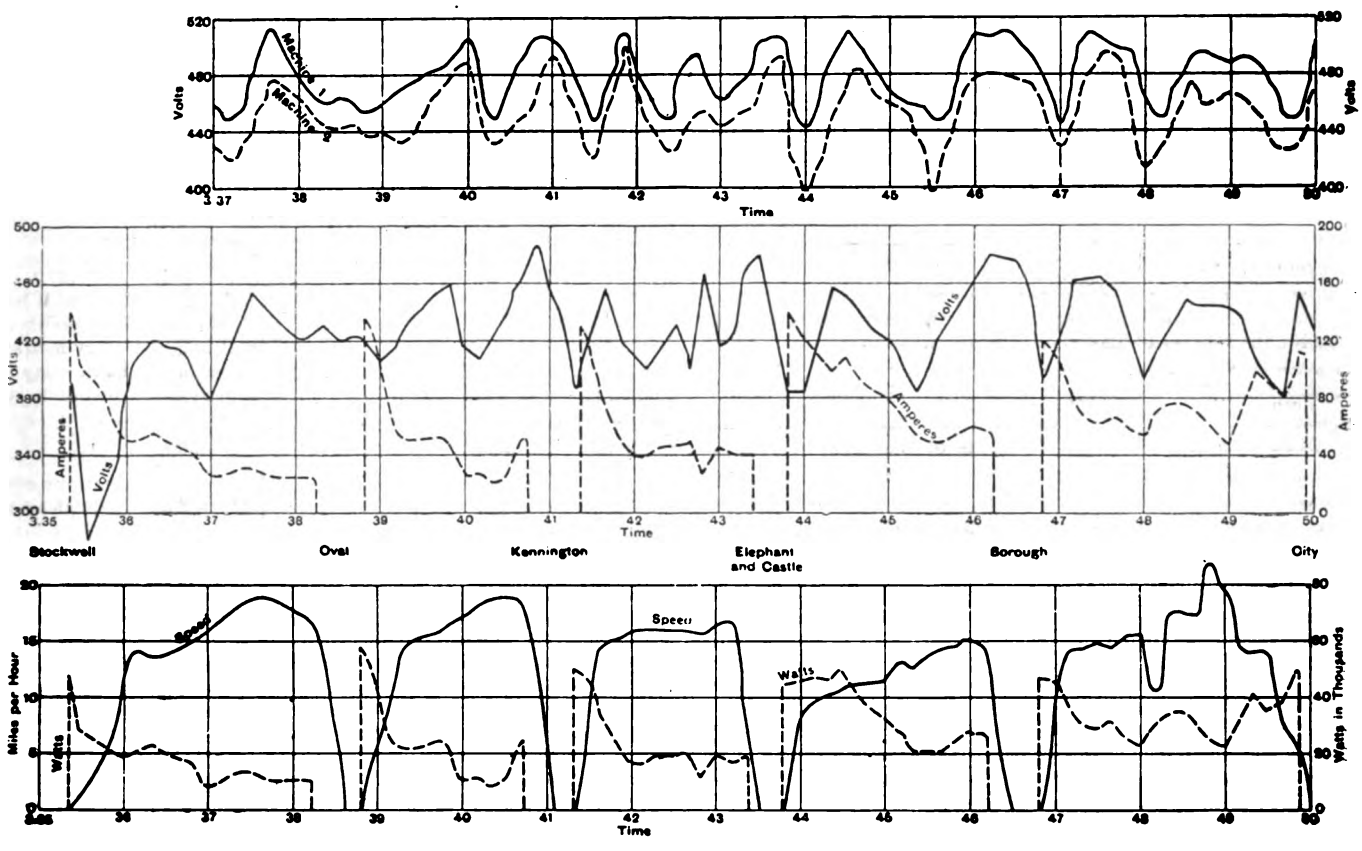

Table A.

Speed in miles per hour.	Electrical H.P. put into motor armature.	Electrical H.P. put into motor magnets.	Total electrical H.P. per motor.	Total electrical H.P. per locomotive.	Brake H.P. measured.	Efficiency per cent.
12·25	56·96	2·8	59·76	119·52	110·0	92·0
14·77	24·42	1·21	25·63	51·26	47·1	91·87
15·7	21·5	0·86	22·36	44·72	40·2	89·89
17·83	21·85	0·74	22·59	45·18	42·62	94·32
22·73	29·23	0·35	29·58	59·16	54·3	91·79
24·7	19·5	0·2	19·7	39·4	36·6	92·68
30·06	26·27	0·17	26·44	52·88	48·76	92·19

* Paper read before the British Association in Section G, Edinburgh, August, 1892.

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Since the two locomotives have been set to work on the railway they have had to keep the same time as the others, so that their full power cannot be utilised, but it has been found that their efficiency is satisfactory in every respect. Observations of the current and electromotive force have recently been made simultaneously by taking sets of readings on the ammeters and voltmeters, both at the generating station and on the locomotive. From these observations the curves accompanying these notes have been plotted. At the time these observations were made the locomotives had run about 8,000 statute miles, and on all four motors the brushes were wearing at the rate of about an eighth of an inch per thousand miles run, this small wear being a consequence of the motors running sparkless and practically without heating.

On examining the curves† it will be noticed that there is no similarity whatever between those representing the volts at the generating station and on the locomotives respectively; this is, however, easily explained by the consideration that the volts at the generating station are influenced by all the trains in motion at the same time, while the volts on each locomotive are principally influenced by the demand of the locomotive itself. When the train is started the current is regulated by the driver, so as not to exceed a certain amount, by means of switches inserting resistances into the main circuit, but these resistances are cut out within half a minute of starting, so that the waste of energy in the resistances is kept as low as possible. Each locomotive fully equipped weighs 13½ tons, and the weight of the train of carriages it has to draw is about 21 tons. To this the weight of the passengers has to be added.

Table B.

—	Watt minutes.	Ampere mins.	Total time including stops.	Mean volts.	Mean amps.	Av. running speed. Miles per hour, exclusive of stops.
Stockwell to City.			m. s.			
Loco. No. 15. Journey 1	322,660	768·65	14 40	419·7	52·41	13·05
„ „ Journey 2	291,995	689·33	14 16	423·6	48·34	13·27
Loco. No. 16. Journey 1	317,640	733·32	14 40	433·2	50·00	13·29
„ „ Journey 2	315,660	751·32	14 50	420·15	50·60	13·41
Mean	311,988	735·65	14 36	424·16	50·33	13·25
City to Stockwell.						
Loco. No. 15. Journey 1	323,665	766·05	15 30	422·5	49·42	12·19
„ „ Journey 2	312,995	737·98	15 26	424·1	47·83	12·58
Loco. No. 16. Journey 1	305,320	717·99	15 8	425·2	47·46	13·21
„ „ Journey 2	321,660	749·31	14 56	429·25	50·19	12·83
Mean	315,910	742·83	15 15	425·26	48·72	12·7
Final mean	313,949	739·24	14 55	424·71	49·52	12·97

A summary of the results is given in Table B, which shows that the average power developed by each locomotive requires a current of not more than about 50 amperes, although in starting as much as 140 amperes are required. This fact illustrates at the same time the peculiar difficulties which have to be grappled with in the construction of such locomotives, which have to work under conditions almost diametrically opposite to those of generating dynamos in Electric Supply Central Stations.

DISCUSSION.

Mr. J. H. GREATHEAD, engineer to the City and South London Railway Company, said the locomotives were very satisfactory, especially as regarded the armatures. It was quite obvious that it had been proved conclusively that electricity would furnish a means of dealing with the traffic in large cities in a most satisfactory way, and quite as economical as could be accomplished by great locomotives in the ordinary manner.

Prof. SILVANUS THOMPSON, in the course of his remarks, said it was a question of design and construction whether they could work the motors with field-magnets giving strong enough intensity to the magnetic field to enable them to work with small currents.

Mr. TRAILL, Antrim, then gave an account of the Giant's Causeway Electric Railway.

Prof. G. FORBES said that the success which had attended the working of the electric locomotives on the City and South London Railway was a sufficient answer to those who held up numerous accidents to armatures in the past, and pointed out that electric traction was still in an experimental stage. The way in which Messrs. Siemens had overcome all the difficulties was the obvious one of making the motor large enough. The critical thing in the working of electric locomotives for traction was not so much the efficiency for a high speed as that at the starting point. It was at the lowest speed that the greatest precaution had to be taken as to the working of the machine.

In replying to the discussion, Mr. SIEMENS said the principal loss at low speeds was caused by the resistances, but whether the motor was a little more efficient or not was really of no consequence whatever.

† [We only reproduce the curves relating to a single journey of No. 15 locomotive from Stockwell to the City. There were several more of the same kind shown by the author.—ED. *E.*]

PROF. SCHUSTER'S PRESIDENTIAL ADDRESS TO SECTION A.

[ABSTRACT.]

We are chiefly concerned here with the increase of scientific knowledge, and we may fairly ask ourselves whether it is possible by means of any systematic course of study or by means of any organisation to accelerate our progress into the dark continent of science. But in choosing the direction in which a change may best be made, I think we may learn something from the way in which Nature improves its organisms. We are taught by biologists that natural selection acts by developing those qualities which enable each species best to survive the struggle for existence; useless organs die off or become rudimentary. To apply these reflections to the questions with which we are specially concerned, I should like to see it more generally recognised that although there is no struggle for existence between different nations, yet each nation, owing to a number of circumstances, possesses it own peculiarities, which render it better fitted than its neighbours to do some particular part of the work on which the progress of science depends. Does it not seem well to let each country take that share of work for which the natural growth of its character and its educational establishment best adapt it?

As far as the work of this section is concerned the strongest domain of this country has been that of mathematical physics. But it is not to this that I wish specially to refer. Look at the work done in Great Britain during the last two centuries; the work not only in physics, but in astronomy, chemistry, biology. Is it not true that the one distinctive feature which separates this from all other countries in the world is the prominent part played by the scientific amateur, and is it not also true that our modern system of education tends to destroy the amateur? By amateur I do not necessarily mean a man who has other occupations and only takes up science in his leisure hours, but rather one who has had no academical training, at any rate in that branch of knowledge which he finally selects for study. Other names will occur to you, the most typical and eminent being that of Joule. It is not my purpose to discuss why distinguished amateurs have been so numerous in this country, but I am anxious to point out that we are in danger of losing one great and necessary factor in the origination of scientific ideas. Whatever is taught in early age must necessarily be taught in a more or less dogmatic manner, and, in whatever way it is taught, experience shows that it is nearly always received in a dogmatic spirit. It seems important, therefore, to confine the early training to those subjects in which preconceived notions are considered an advantage. If school examinations could be more general, if scientific theories could only be taught at an age when a man is able to form an independent judgment, there might be some hope of retaining that originality of ideas which has been a distinctive feature of this country, and enabled our amateurs to hold a prominent position in the history of science. At present a knowledge of scientific theories seems to me to kill all knowledge of scientific facts.

But while it is necessary to recognise the great work done by the unprofessional scientists, it seems not untimely to draw their attention to the damage done to themselves if they overstep their legitimate boundaries, and especially if they seek popular support for their theories, which have not received the approval of those who are competent to judge. An appeal from Alexander sober to Alexander drunk will not prove successful in the end.

The gradual disappearance of the amateur may be a necessary consequence of our increased educational facilities, and we must inquire whether any marked advantages are offered to us in exchange. There is one direction in which it would seem at first sight, at any rate, that a proper course of study could do much to facilitate the progress of research. On another occasion I pointed out that two parties are necessary for every advance in science, the one that makes it and the one that believes in it. If the discoverer is born, and cannot be made, would it not be possible at any rate to train the judgment of our students so that they may form a sound opinion on the new theories and ideas which are presented to them? It is too early as yet to judge in how far our generation is better in this respect than the one that has gone before them; but on closer examination it does not seem to me to be obvious that any marked improvement is possible. But looking back at the history of science during the present century, is there much evidence that great discoveries have been seriously delayed by want of proper appreciation? The point is not one of academic interest only, for the fear of re-

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pressing some important new discovery has a detrimental influence in another direction. The judgment of the scientific world seems to me to be tending too much towards leniency to apparently absurd theories, because there is a remote chance that they may contain some germ of real value. A new truth will not be found to suffer ultimately by adverse and even unreasonable criticism, while bad theories and bad reasoning, supported by the benevolent neutrality of those to whose judgment the scientific world looks for guidance, are harmful in many ways. They block the way to an independent advance, and encourage hasty and ill-considered generalisations. The conclusions I should draw from the considerations I have placed before you are these: I believe that a reasonable censorship exercised by our scientific societies is good and necessary; that those whose fate it is to be called on to express an opinion on some work or theory should do so fearlessly according to their best judgment. Their opinion may be warped by prejudice, but I think it is better that they should incur the risk of being ultimately found to be wrong than that they should help in the propagation of bad reasoning. There is one matter, however, on which all opinions must agree. Worse than bad theory or logic is bad experimental work. Should we then not rigorously preserve any influence or incentive which encourages the beginner to avoid carelessness and to consider neither time nor trouble to secure accuracy? There is no doubt to my mind that the prospect of admission to the Royal Society has been most beneficial in this respect, and that the honourable ambition to see his Paper published in the *Transactions* of that Society has preserved many a student from the premature publication of unfinished work.

One of the principal obstacles to the rapid diffusion of a new idea lies in the difficulty of finding suitable expression to convey its essential point to other minds. Words may have to be strained into a new sense, and scientific controversies constantly resolve themselves into differences about the meaning of words. On the other hand, a happy nomenclature has sometimes been more powerful than rigorous logic in allowing a new train of thought to be quickly and generally accepted. A good example is furnished by the history of the science of energy. The principle of the conservation of energy has undoubtedly gained a more rapid and general acceptance than it would otherwise have had by the introduction of the word potential energy. A great theorem, which in itself seems to me to be an intricate one, has been simplified by calling something energy which, in the first place, is only a deficiency of kinetic energy. The only record I can find on the history of the expression is given in Tait's "Thermodynamics," wherein the term "statical energy" is ascribed to Lord Kelvin, and that of "potential energy" to Rankine. It would be of interest to have a more detailed account on the origin of an expression which has undoubtedly had a marked influence not only on the physics but also on the metaphysics of our time. But while fully recognising the very great advantage we have derived from this term "potential energy," we ought not, at the same time, to lose sight of the fact that it implies something more than can be said to be proved.

In the expressions we adopt to prescribe physical phenomena we necessarily hover between two extremes. We either have to choose a word which implies more than we can prove, or we have to use vague and general terms which hide the essential point, instead of bringing it out. The history of electrical theories furnishes a good example. The terms positive and negative electricity committed us to something definite; we could reckon about quantities of electricity, and form some definite notion of electrical currents as a motion of the two kinds of electricity in opposite directions. Now we have changed all that; we speak of electric displacements, but safeguard ourselves by saying that a displacement only means a vector quantity, and not necessarily an actual displacement. We speak of lines and tubes of force not only as a help to realise more clearly certain analytical results, but as implying a physical theory to which, at the same time, we do not wish to commit ourselves. I do not find any fault with this, for it is a perfectly legitimate and necessary process to state the known connection between physical phenomena in some form which introduces the smallest number of assumptions. But the great question, "What is electricity?" is not touched by these general considerations. The brilliant success with which Maxwell's investigations have been crowned is apt to make us overrate the progress made in the solution of that question. Maxwell and his followers have proved the important fact that optical and electrical actions are transmitted through the same medium. We may be said to have arrived in the subject of electricity at the stage in which optics was placed before Young and Fresnel hit on the idea of transverse vibrations; but there is no theory of electricity in the sense in which there is an elastic solid theory of light.

If the term "electrical displacement" was taken in its literal sense it would mean that the electric current consists of the motion of the ether through the conductor. This is a plausible hypothesis, and one respecting which we may obtain experimental evidence. The experiments of Rayleigh and others have shown that the velocity of light in an electrolyte, through which an electric current is passing, is, within experimental limits, the same with and against the current. The result shows that if an electrical current means a motion of the ether the velocity of the medium cannot exceed ten metres a second for a current density of one ampere per square centimetre. This, then, is the upper limit for a possible velocity of the medium. Can we find a lower limit? The answer to that question depends on the interpretation of a well-known experiment of Fizeau's, who found that the speed of light is increased if it travels through water which moves in the same direction as the light. If this experiment implies that the water carries the ether with it, and if a motion of the ether means an electric current, we should be led to the conclusion that a current of water should deflect a magnet in its neighbourhood. An experiment made to that effect would almost certainly give a negative result, and would give us a lower limit for the velocity of the medium corresponding to a given current. Such an experiment, together with that of Rayleigh, would probably dispose of the theory that an electric current is due to a translatory velocity of the medium. This would be an important step, and it would be worth while to arrive at a final settlement of the question.* The whole question of the relation between the motion of matter and motion of the medium is a vital one, and we shall probably not make any serious advances until experiment has found a new opening. But we must expect many negative results before some clue is discovered. Nor can we attach much importance to negative results unless they are made by some one in whose care and judgment we place full reliance. We should all the more, therefore, recognise the courage and perseverance of those who spend their valuable time in such investigations as Prof. Lodge has recently undertaken. That ultimately some relation will be found between moving matter and electrical action there is no reasonable doubt.

One of the most hopeful openings for new investigations has always been found in the pursuing of a theory to its logical conclusions, and there is one result of the electro-magnetic theory of light which has not, in my opinion, received the share of attention which it deserves. When sound passes through air it is propagated more quickly with the wind than against it, and we may easily find the velocity relative to the earth by combining the ordinary sound velocity with the velocity of the wind. Similarly, when any waves pass through a medium moving with uniform velocity, the waves being due to internal stresses in the medium, we may treat of the velocity of the waves independently of that of the medium, and say that the wave-velocity in the direction of motion of the medium, and relative to a fixed body, is the sum of the wave velocity, calculated on the supposition that the medium is at rest and the velocity of the medium. Prof. J. J. Thomson,† applying Maxwell's equations, has arrived at a different result for electro-magnetic waves, and has come to the conclusion that in order to get the velocity of light along a stream of flowing water we have to add to the velocity of light only half the velocity of water. The following considerations suggest themselves to me with respect to this result. Maxwell's theory is founded on certain observed effects, which all depend on the relative motion of matter. A result such as the one referred to implies actions depending on absolute motion, and appears therefore to point to something which has been introduced into the equations for which there is no experimental evidence. The only assumption clearly put down by Maxwell is that electro-magnetic actions are transmitted through the medium, and it is possible that that assumption necessarily carries Prof. J. J. Thomson's result with it. If a careful examination of the subject should show that this is the case, we are brought face to face with a serious difficulty. It is said, with justice, to be one of the great advantages of Maxwell's theory that it does away with action at a distance; but what do we gain if we replace action at a distance by something infinitely more difficult to conceive, namely, internal stresses of a medium depending on the velocity of the medium through space? I can only see one loophole through which to escape, namely, that Maxwell's medium is not homogeneous, but consists of two parts, and that if we speak of the medium as moving, we mean the motion of one of these parts relative to the other.

While we may hope to obtain important results from an investigation of the relation between what we call electricity and the medium, we must not lose sight of another avenue, namely, the relation between electricity and chemical effects. The passage of electricity through gases presents us with a complicated problem to

* Fizeau's results must either be due to the motion of matter through the medium or to the fact that moving matter carries the ether with it. If it is due to the former cause, and matter does *not* carry the ether with it, may we not consider that matter moving through the ether—that is, a relative motion of matter and ether—must produce effects equal and opposite to those of ether moving through matter? In that case the reasoning in the text would, *mutatis mutandis*, hold good.

† *Phil. Mag.*, Vol. IX., p. 284 (1880).

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which a number of physicists have given their attention of late years. There seems no reasonable doubt that electricity in a gas is conveyed by the diffusion of particles conveying high charges, probably identical with those carried by the electrolytic ion. The fact that this convection is a process of diffusion with comparatively small velocity is shown by the experimental result that the path of the discharge is affected by any bodily motion of the gas which conveys the current. Even the convection currents due to the heat produced by the discharge itself are sufficient to deflect the luminous column which marks the passage of the current. The most puzzling fact, however, connected with the discharge of electricity through gases consists in the absence of symmetry at the positive and negative poles. There must be some difference between a positively and negatively charged atom which seems of fundamental importance in the relation between matter and what we call electricity. A discussion of the various phenomena attending the discharge of electricity through gases seems to me to point to a conclusion which may possibly prove a step in the right direction.

A surface of separation between bodies having different conductivities becomes electrified by the passage of a current, while at the surface between two chemically distinct bodies we have, according to Helmholtz, a sheet covered at the two sides with opposite electricities. These surface electrifications are not merely imaginary layers invented to satisfy mathematical surface conditions. They can be proved to be realities. Thus, when one electrolyte floats on another, the specific resistances being different, we often observe secondary chemical effects due to the action of the ions which carry the surface electrification.

If the passage of electricity from the solid to the gas involves some work done, we must expect a double sheet of electricity at the boundary, the gas in contact with the cathode becoming positively, and that in contact with the anode negatively, electrified. *A priori* we can form no idea how a layer of gas, the atoms of which carry charges, will behave. The ordinary proof that all electrification must be confined to the surface implies that all forces act according to the law of the inverse square ; but where we have also to consider molecular forces, I see no reason why the electrification at a surface may not stretch across a layer having a thickness comparable with the mean free path of the molecule. It is here that there seems to be the fundamental difference between positive and negative electricity. A negative electrification of the gas, like that of a solid or a liquid, seems always confined to the surface, and no one has ever observed a volume electrification of negative electricity. The case is different for the positively electrified part of the gas. Wherever from other considerations we should expect a positively electrified surface sheet, we always get a layer of finite thickness. The result implies a different law of impact between positively and negatively electrified ions, but I see no inherent improbability in this. That the cathode let into a gas is surrounded by a positively electrified layer of finite thickness extending outwards must be considered as an established fact, and several of the characteristic features of the discharge are explained by it. The large fall of potential at the cathode can also be explained on the view which I have put forward ; for in order to keep up the discharge there must be a sufficient normal force at the surface, and if this force is not confined to the surface, but necessarily stretches across a finite layer, the fall of potential must be multiplied a great number of times. Similarly Goldstein has shown that some of the phenomena of the cathode are observed at every place at which the positive current flows from a wide to a narrow part of a column of gas. At such places we should expect a positive surface electrification ; and here, again, the whole appearance tends to show that we are dealing with a positive volume electrification. No corresponding phenomena are observed when the current passes from the narrow to the wide part.

The fact that in all cases experimented upon positive volume electrifications are observed but never similar negative electrifications is surely of significance.

Some of the results recently brought to light by investigations on the discharge of electricity have interesting cosmical applications. Thus it is found that such a discharge through any part of a vessel containing a gas converts the whole gas into a conductor.* There are other ways in which a gas can be put into that sensitive state in which we may treat it as a conductor, and we have every reason to suppose that the upper regions of our atmosphere are in this state. The principal part of the daily variation of the magnetic needle is due to causes lying outside the surface of the earth, and is in all probability only an electro-magnetic effect due to that bodily motion in our atmosphere which shows itself in the diurnal changes of the barometer. A favourite idea of the late Prof. Balfour Stewart will thus probably be confirmed. The difference in the diurnal range between times of maximum and times of minimum sunspots is accounted for by the fact that the atmosphere is a better conductor at times of maximum sunspots. The mention of sunspots raises a point not altogether new to this Section. Careful observation of celestial phenomena may suggest to us the solution of many mysteries which are now puzzling us. Consider, for instance, how long it would have taken to prove the universal property of gravitational attraction if the record of planetary motion had not come to the philosopher's help. And surely the most casual observation of cosmical effects teaches us how much we have yet to learn. The statement of a problem occasionally helps to clear it up ; and I may be allowed, therefore, to put before you some questions, the solution of which seems not beyond the reach of our powers.

1. Is every large rotating mass a magnet? If it is, the sun must be a powerful magnet. The comets' tails, which eclipse observations show stretching out from our sun in all directions, probably consist of electric discharges. The effect of a magnet on the discharge is known, and careful investigations of the streamers of the solar corona ought to give an answer to the question which I have put.*

2. Is there sufficient matter in interplanetary space to make it a conductor of electricity? I believe the evidence to be in favour of that view. But the conductivity can only be small, for otherwise the earth would gradually set itself to revolve about its magnetic pole. Suppose the electric resistance of interplanetary space to be so great that no appreciable change in the earth's axis of rotation could have taken place within historical times, is it not possible that the currents induced in planetary space by the earth's revolution may, by their electro-magnetic action, cause the secular variation of terrestrial magnetism? There seems to me to be here a definite question capable of a definite answer, and, as far as I can judge without a strict mathematical investigation, the answer is in the affirmative.

3. What is a sunspot? It is, I believe, generally assumed that it is analogous to one of our cyclones. The general appearance of a sunspot does not show any marked cyclonic motion, though what we see is really determined by the distribution of temperature and not by the lines of flow. But a number of cyclones clustering together like the sunspots in a group should move round each other in a definite way ; and it seems to me that the close study of the relative positions of a group of spots should give decisive evidence for or against the cyclone theory.

4. If the spot is not due to cyclonic motion, is it not possible that electric discharges setting out from the sun, and accelerating artificially evaporation at the sun's surface, might cool those parts from which the discharge starts, and thus produce a sunspot? The effects of electric discharges on matters of solar physics have already been discussed by Dr. Huggins.

5. May not the periodicity of sunspots, and the connection between two such dissimilar phenomena as spots on the sun and magnetic disturbances on the earth, be due to a periodically recurring increase in the electric conductivity of the parts of space surrounding the sun? Such an increase of conductivity might be produced by meteoric matter circulating round the sun.

6. What causes the anomalous law of rotation of the solar photosphere? It has long been known that groups of spots at the solar equator perform their revolution in a shorter time than those in a higher latitude ; but spots are disturbances which may have their own proper motions. As all causes acting within the sun might cause the angular velocity of the sun to be smaller at the equator than at other latitudes, but could not make it greater, the only explanation open to us is an outside effect either by an influx of meteoric matter, as suggested by Lord Kelvin, or in some other way. The exceptional behaviour of the solar surface seems to me to deserve very careful attention from solar physicists. Its explanation will probably carry with it that of many other phenomena.

In conclusion, I should like to return for an instant to the question whether it is possible by any means to render the progress of science more smooth and swift. We hear it said that the British Association has fulfilled its object ; we are told that it was originally founded to create a general interest in scientific problems in the towns in which it meets ; and now that popular lectures and popular literature are supposed to perform that work more satisfactorily, we are politely asked to commit the happy despatch. There is no need to go back to the original intention of those who have founded this institution, which has at any rate adapted itself sufficiently well to the altered circumstances to maintain a beneficial influence in scientific research. The free discussion which takes place in our Sections, the interchange of ideas between men who during the rest of the year have occupied their minds, perhaps too much, with some special problem, the personal intercourse between those who are beginning their work with sanguine expectations, and those who have lost the first freshness of their enthusiasm, should surely one and all ensure a long prosperity to our meetings. If we cannot claim any longer to sow the seeds of scientific interest in

* An experiment by Hittorf (*Wied. Ann.*, VII., p. 614) suggested the probability of this fact, which was proved independently by Arrhenius and myself.

* The efforts of Mr. Bigelow have a bearing on this point, also some remarks which I have made in a lecture before the Royal Institution (*Proc. Roy. Inst.* 1891), but nothing decisive can be asserted at present.

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the towns we visit, because the interest is established, we can at any rate assure those who so kindly offer us hospitality that they are helping powerfully in the promotion of the great object which we all have at heart.

PROF. UNWIN'S PRESIDENTIAL ADDRESS TO SECTION G.

[ABSTRACT.]

The year just passed is not one unmemorable in the annals of engineering. The broad-gauge system has been extinguished. The past year has seen the completion of the magnificent scheme of water supply for Liverpool from the Vyrnwy. This is one of the largest and most striking of those works of municipal engineering rendered necesssary by the growth of great city communities, and made possible by their wealth and public spirit. Since the construction of the Vyrnwy dam, another very large dam, the Tansa dam, has been completed in Bombay. In the United States a still greater work of the same kind has been commenced on the Croton river, in connection with the water supply of New York. A scheme of water supply for Manchester from Lake Thirlmere, in Westmoreland, is approaching completion. Birmingham is likely to carry out another work of the same kind, and London, at a greater distance from pure water sources, and under greater difficulties from the complexity of existing interests, has come to realise that, within 50 years, a population of 12½ millions will probably have to be provided for. To supply such a population, a volume of water is required ten times as great as the whole available supply from Lake Vyrnwy.

Here in Edinburgh one remembers that the birthplace of the steam-engine is near at hand. A century and a quarter ago, James Watt made an invention which has profoundly influenced all the conditions of social, national, commercial, and industrial life. So great was Watt's insight into the action of the engine that he was able to leave it so perfect that, except in one respect, little remained for succeeding engine builders, except to perfect the machines for its manufacture, to improve its details and to adapt it to new purposes. Now it very early became clear that there were two directions of advance which ought to secure greater economy. Simple mechanical indications showed that increased expansion ought to ensure increased economy. Thermo-dynamic considerations indicated that higher pressures, involving a greater temperature range of working, ought to secure greater economy. But in attempting to advance in either of these directions, engineers were more or less disappointed. Some of Watt's engines worked with 5lb. of coal per indicated horse-power per hour. Many engines with greater pressures and longer expansions have done but little better. The history of steam-engine improvement for a quarter of a century has been an attempt to secure the advantages of high pressures and high ratios of expansion. The difficulty to be overcome has proved to be due to the same cause as the inefficiency of Watt's model engine. The separate condenser diminished, but it did not annul the action of the cylinder wall. The first experiments which really startled thoughtful steam engineers were those made by Mr. Isherwood between 1860 and 1865. Very little later than this M. Hirn undertook, in 1871-5, his classical researches on the action of the steam in an engine of about 150 I.H.P. Experiments of greater accuracy or completeness, or of a greater insight into the conditions which were important, have never since been made. Hirn originated a complete method of analysis of an engine test, showing at every stage of the operation the heat accounted for and a balance of heat unaccounted for; and the latter proved to be a very considerable quantity. Meanwhile theoretical writers, especially Rankine and Clausius, had been perfecting a thermo-dynamic theory of the steam engine, based primarily on the remarkable and irrefragable principle of Carnot. The result of Hirn's analysis was to show that these theories, applied to the actual steam engine, were liable to lead to errors of 50 or 60 per cent., the single false assumption being made that the interaction between the walls of the cylinder and the steam was an action small enough to be negligible.

In this country Mr. Mair Rumley, following Hirn's method, made a series of experiments on actual engines with great care and accuracy and completeness. All these experiments demonstrated the fact of a large initial condensation of steam on the walls of the cylinder, alike in jacketed and unjacketed engines. This condensed steam is re-evaporated partially during expansion, but mainly during exhaust, and serves as a mere carrier of heat from boiler to condenser, in conditions not permitting its utilisation in producing work. It became clear from Hirn's experiments, if not from the earlier experiments of Isherwood, that for each engine there is a particular ratio of expansion for which the steam expenditure per horse-power is least. Prof. Dery has since deduced from them that the practical condition of securing the greatest efficiency is that the steam at release should be nearly dry. In producing that dryness the jacket has an important influence. In spite of much controversy amongst practical engineers about the use of the jacket, it does not appear that any trustworthy experiment has yet been adduced in which there was an actual loss of efficiency due to the jacket. In the older type of comparatively slow engines it is a rule that the greater the jacket condensation the greater the economy of steam, even when the jacket condensation approaches 20 per cent. of all the steam used. It appears, however, that as the speed of the engine increases, the influence of the jacket diminishes, so that for any engine there is a limit of speed at which the value of the jacket becomes insignificant.

Among steam-engine experiments directed specifically to determine the action of the cylinder walls, those of the late Mr. Willans should be specially mentioned. Mr. Willans's death is to be deplored as a serious loss to the engineering profession. His steam-engine experiments, some of them not yet published, are models of what careful experiments should be. They are graduated experiments designed to indicate the effect of changes in each of the practically variable conditions of working. They showed a much greater variation of steam consumption (from 46lb. to 18lb. per indicated horse-power hour) in different conditions of working than, I think, most practical engineers suspected, and this has been made more significant in later experiments, on engines working with less than full load. The first series showed that in full-load trials the compound was superior to the single engine in practically all the conditions tried, but that the triple was superior to the compound only when certain limits of pressure and speed were passed.

As early as 1878 Prof. Cotterill had shown that the action of a cylinder wall was essentially equivalent to that of a very thin metallic plate, following the temperature of the steam. The exceedingly rapid dissipation of heat from the surface during exhaust especially being due to the evaporation of a film of water initially condensed on its surface. Recently Prof. Cotterill has been able to carry much further the analysis of the complex action of condensation and re-evaporation in the cylinder, and to discriminate in some degree between the action of the metal and the more ambiguous action of the water film. By discarding the less important actions, Prof. Cotterill has found it possible to state a semi-empirical formula for cylinder condensation in certain restricted cases which very closely agrees with experiments on a wide variety of engines. It is to be hoped that, with the data now accumulating, a considerable practical advance may be made in the clearing up of this complex subject. Interpreted by what is already known of thermo-dynamic actions, there are very few trustworthy engine tests which do not fall into a perfectly intelligible order.

There is only one known method, not now much used, by which the cylinder condensation can be directly combated. Thirty years ago superheating the steam was adopted with very considerable increase of economy. It is likely that it was thought by the inventor of superheating that an advantage would be gained by increasing the temperature range. If so, his theory was probably a mistaken one. For the cooling action of the cylinder is so great that the steam is reduced to saturation temperature before it has time to do work, but the economy due to superheating was unquestionable, and was very remarkable, considering how small a quantity of heat is involved in superheating. The heat appears to diminish the cylinder-wall action so much as almost to render a jacket unnecessary. The plan of superheating was abandoned from purely practical objections, the superheaters then constructed being dangerous. Recently superheating has been tried again at Mulhouse by M. Meunier, and his experiments are interesting because they are at higher pressures than in the older trials and with a compound engine. It appears that even when the superheater was heated by a separate fire there was an economy of steam of 25 to 30 per cent. and an economy of fuel of 20 to 25 per cent., and four boilers with superheating were as efficient as five without it. It may be pointed out as a point of some practical importance that if a trustworthy method of superheating could be found, the advantage of the triple over the compound engine would be much diminished. For marine purposes the triple engine is perfectly adapted. But for other purposes it is more costly than the compound engine, and it is less easily arranged to work efficiently with a varying load. There does not seem much prospect of exceeding the efficiency attained already in the best engines, though but few engines are really as efficient as they might be, and there are still plenty of engines so designed that they are exceedingly uneconomical. The very best engines use only from 12lb. to 13lb. of steam per indicated horse-power hour, having an absolute efficiency reckoned on the indicated power of 16 per cent., or reckoned on the effective power, 13 per cent. The efficiency, including the loss in the boiler, is only about 9 per cent. But there are internal furnace engines of the gas-engine or oil-engine type in which the thermal efficiency is double this.

In his interesting address to this Section in 1878, Mr. Easton expressed the opinion that the question of water-power was one

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deserving more consideration than it had lately received, and he pointed to the variation of volume of flow of streams as the principal objection to their larger utilisation. Since that time the progress made in systems of transporting and distributing power has given quite a new importance to the question of the utilisation of water-power. There seems to be a probability that in many localities water-power will, before long, be used on a quite unprecedented scale, and under conditions involving so great convenience and economy that it may involve a quite sensible movement of manufactures towards districts where water-power is available. The whole tendency of the conditions created by the use of steam power has been to concentrate the industrial population in large communities, and to restrict manufacturing operations to large factories. The whole social conditions of manufacturing centres have been profoundly influenced by these two conditions—that coal for raising steam can be easily brought to any place where it is wanted, and that steam power is more cheaply produced on a large scale than on a small scale. It looks rather, just now, as if facilities for distributing power will to some extent reverse this tendency. Let me first point out that water power, where it is available, is so much cheaper and more convenient than steam power that it has never been quite vanquished by steam power. I find, from a report by Mr. Weissenbach, that, in 1876, 70,000 H.P. derived from waterfalls were used in manufacturing in Switzerland. According to a census in 1880, it appears that the total steam and water power employed in manufacturing operations in the United States was 3,400,000 H.P. Of this, 2,185,000 H.P., or 64 per cent., was derived from steam, and 1,255,000 H.P., or 36 per cent., from water. In the manufacture of cotton and woollen goods, of paper, and of flour, 760,000 H.P. were obtained from water, and 515,000 H.P. from steam. If the statistics could be obtained from other countries, I believe it would be found that a very large amount of water power is actually made available. With a very limited exception, all the water-power at present used is employed in the neighbourhood of the fall where it is generated. If means were available for transporting the power from the site of the fall to localities more convenient for manufactures, there can be no doubt that a much larger amount of water-power would be used, and the relative importance of water and steam-power in some countries would probably be reversed. It is because recent developments seem to make such a transport of power possible without excessive cost, and without excessive loss, that a most remarkable interest has been excited in the question of the utilisation of water-power. Take the case of Switzerland, for instance. At the present time Switzerland is said to pay to other countries £800,000 annually for coal. But the total available water-power of Switzerland is estimated at no less than 582,000 H.P., of which, probably, only 80,000 are at present utilised.

First, then, let me say a few words as to modes of distributing power which it is possible to adopt. Wire rope transmissions are of great mechanical simplicity, and the loss of power in transmission is exceedingly small. They are extremely suitable for certain cases where a moderate amount of power has to be transmitted a moderate distance—to one or to a few factories. On the other hand, they become cumbrous if the amount of power transmitted exceeds 600 H.P. or 1,000 H.P. The wear of the ropes, which only last a year, has proved greater than was expected, and is a source of considerable expense.

The practical introduction of a system of distributing power by pressure water is due to Lord Armstrong. Such a system involves central pumping station, a series of distributing mains, and suitable working motors. From its first introduction the peculiar advantages of this system for driving intermittently working machines, such as lifts, dock machinery, railway cranes, and hauling gear, became obvious. But, with intermittent working machines, there arose the need of an appliance for storing energy during periods of minimum demand, and restoring it in periods of maximum demand. The invention of the accumulator by Lord Armstrong made the system of hydraulic transmission a success, and at the same time fixed its character as a system specially adapted for those cases where intermittent work is required to be done. Lord Armstrong's system of hydraulic distribution by water at a pressure of 700lb. or 800lb. per square inch, with the use of accumulators for equalising the variations of supply and demand, has now been widely adopted. The most extensive scheme of that kind hitherto executed is the important scheme carried out by the Hydraulic Power Company. Over 50 miles of pressure mains have now been laid in the streets of London. The Falcon Wharf pumping station contains four sets of compound pumping engines, each of 200 H.P. Two additional pumping stations have now been erected, and 1,500 lifts are worked from the pressure mains. The minimum charge for water is 2s. per 1,000 gallons. This rate of charge is economical for such machines as lifts, but it would be extravagant for machines working continuously. It would be equivalent to a charge of nearly £50 per horse-power per year of 3,000 working hours, apart from interest and maintenance of machines.

But neither teledynamic transmission nor hydraulic transmission have proved suitable as methods for the general distribution of motive power from central stations. Distribution by steam and distribution by heated water have both been tried in the United States, but not with very remarkable success. Only two other methods are available, distribution by compressed air and distribution by electricity. For many years compressed air has been used to distribute power in tunnelling and mining operations to considerable distances. It is only recently that it has been used as a general method of distributing power to many consumers. It is through experience gained and improvements carried out in the remarkable system now at work in Paris, and known as the Popp system, that the great advantages of compressed air distribution have been proved. In 1889 steam air compressors of 2,000 H.P. were at work, and additional compressors were under construction. The pressure at that time was five atmospheres, and the largest air mains were 12in. in diameter. Ingenious and simple rotary machines were used as air motors for small powers, and for larger powers any ordinary steam-engine was converted into an air motor. Prof. Kennedy made tests in 1889. He found that a motor four miles from the compressing station indicated 10 H.P. for 20 I.H.P. expended at the compressing station, an efficiency of 50 per cent. only. There were then 225 motors worked from the air mains. Since 1889 more extended investigations have been made by Prof. Riedler, of Berlin, and the chief part of the waste of work has been traced to inefficiency of the air compressors. Compound air compressors of much higher efficiency have now been constructed. The plant at the St. Fargeau station has been increased to 4,000 H.P. A new station has been erected on the Quai de la Gare, intended ultimately to contain compressors of 24,000 H.P Compressors of 10,000 H.P. are already under construction. Compressed air transmission, whether or not it is the most economical system, is undoubtedly applicable for the distribution of power on a very large scale and to very considerable distances. There is nothing in any of the appliances which is novel or imperfectly understood. The air is used in the consumer's premises in machinery of well-understood types, and old steam engines can be converted into air motors without difficulty and without alteration of existing transmissive machinery in the factories. Not least important, the air can be measured with accuracy enough for practical purposes by simple meters, and charged for in proportion to the power consumed. Air compressors and air motors are not as efficient as dynamos and electric motors, but in one respect distribution by air and electricity are similar. For distances which are not more than a few miles the loss of energy in transmission is small enough to be insignificant.

About electrical distribution of power I shall not venture to say much, partly because I am not an electrical expert, partly because it has been lately pretty fully discussed. But electrical power distribution to private consumers for industrial purposes has not yet made as much progress as might have been expected.

I have spoken of the growth of a demand for power distributed in a convenient form in towns. The power distribution in London, Manchester, Birmingham, and Liverpool by pressure water, and that by compressed air in Paris, shows how rapidly, when power is available, a demand for it arises. A striking instance may be found in the small town of Geneva. In 1871, soon after the completion of the earlier system of low-pressure water supply, Colonel Turrettini applied to the Municipal Council to place a pressure engine on the town mains for driving the factory of the Society for Manufacturing Physical Instruments. The plan proved so convenient that nine years after, in 1880, there were in Geneva 111 water-motors supplied from the low-pressure mains, using 34,000,000 cubic feet of water annually, and paying to the municipality nearly £2,000 a year. The cost of the power was not low. It was charged at a rate equivalent to from £36 to £48 per horse-power per year of 3,000 working hours. But even the high price did not prevent the use of power so conveniently obtainable. Since then a high-pressure water service has been established, the water being pumped by turbines in the Rhone. From this high-pressure service power is supplied more cheaply. On the high-pressure system the cost of the power is about 0·7d. per horse-power hour, or £8 per horse-power for 3,000 working hours. In 1889 the annual income from water sold for power purposes on the low-pressure system was £2,085, and on the high-pressure system £4,500. On the high-pressure system the receipts in 1889 were increasing at the rate of £880 per year. In 1889 the motive power distributed on the high-pressure system alone amounted to 1,500,000 H.P. hours, there being 79 motors of an aggregate working power of 1,279 horses. In Zurich there is a quite similar system and power, amounting to 9,000,000 H.P. hours in the year, distributed hydraulically to various consumers who pay a rental of £1,200 per annum. It will be noted that all this power in Geneva and Zurich is obtained from water which has been pumped, and it is the low cost of the water power which does the pumping which makes this possible. But further, in both Geneva and Zurich the whole of the dynamos

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supplying electric light are also driven by turbines using pumped water. The convenience of this arises in this way. The fall obtainable in the river in both cases is a small one, and varies. Large turbines are required, and these cannot work at a constant speed. Further, it is expensive to use these large low-pressure turbines to drive directly dynamos which only work with a considerable load for a short portion of the day. The low-pressure turbines in the river are therefore used to pump water to a high-level reservoir, and they work with a constant load all the 24 hours. From the high-level reservoir water is taken as power is required to drive the dynamos, and the turbines driving the dynamos are small high-pressure turbines, working always on a constant fall at a regular speed, and easily adjusted by a governor to a varying load. The system seems a roundabout one, but it is perfectly rational, effective, and economical.

Few persons can have seen Niagara Falls without reflecting on the enormous energy which is there continuously expended, and for any useful purpose wasted. The exceptional constancy of the volume of flow, the invariability of the levels, the depth of the plunge over the escarpment, the solid character of the rocks, all mark out Niagara as an ideally perfect water-power station; while, on the other hand, the remarkable facilities of transport, both by steam navigation on the lakes and by four systems of railway, afford commercial advantages of the highest importance. From a catchment basin of 240,000 square miles, an area greater than that of France, a volume of water amounting to 265,000 cubic feet per second descends from Lake Erie to Lake Ontario, a vertical distance of 326ft., in 37½ miles. Supposing the whole stream could be utilised, it would supply 7,000,000 H.P. This is more than double the total steam and water power at present employed in manufacturing industry in the United States. It was not, however, till about 30 years ago that any systematic attempt was made to utilise part of the water-power of the Falls. Then a canal was constructed from Port Day, about three-quarters of a mile above the Falls, to a forebay or head-race along the cliff overlooking the lower river. In 1874 the Cataract Mill was established, taking power from this canal, and other mills were gradually erected till about 6,000 H.P. was utilised. These mills have been exceedingly prosperous. but since the growth of a feeling against the disfigurement of the Falls it has become impossible to extend works of the same kind. In 1886 the Niagara Falls Company was incorporated. In 1889 the Cataract Construction Company was formed to mature and carry out the constructional works required. The present plans contemplate the utilisation of 100,000 effective horse-power. The principal work of construction is a great tunnel, 7,250ft. long, which is to form a tail-race to the turbines, starting from land belonging to the company, and discharging into the lower river. The tunnel is 19ft. by 21ft., or 386 sq. ft. in area, inside a brickwork lining 16in. thick. The base of the tunnel is 205ft. below the sill of the head gate, and permits a fall of 140 to be rendered available at the turbines. The brickwork of the tunnel is lined for 200ft. from the mouth with cast-iron plates. The tunnel has been excavated with remarkable rapidity with the aid of drills worked by compressed air. The main head-race, about 200ft. wide, will run for about 5,000ft., parallel with the river, having entrances from the river at both ends. Near the lower reach the Soo Paper Company is already arranging to utilise 6,000 H.P., discharging the water from the turbines through a lateral tunnel into the main tunnel. Near this lower reach will also be placed two principal power stations, from which power will be distributed, either electrically or otherwise, in ways not yet fully determined. The first turbines to be erected in these power stations will be twin turbines of the outward-flow type of 5,000 effective horse-power. These turbines have a vertical shaft for driving dynamos or other machinery placed above ground. According to original plans it was intended to distribute water by surface canals to different power users, each of whom would sink his own turbine pits, connected below by lateral tunnels to the main discharge tunnel. Some of the power at Niagara will undoubtedly be used in this way; and in the case of industries requiring a large amount of power it will be economical to purchase a site and water rights. Such a plan is, however, not adapted to smaller factories. Obviously for them it would be more economical to develop the power in one or more central stations by turbines of large size under common management. Further, once given the means of distributing power instead of water, an important extension of the project becomes possible. Besides supplying power to industries which may locate themselves at Niagara, the power may be transmitted to the existing factories in Buffalo and Tonawanda. Arrangements are already proceeding to transmit 3,000 H.P. to Buffalo, a distance of 18 miles, to work an electric lighting station.

In 1890, the President of the Niagara Construction Company visited Europe to examine systems of power distribution. It was in consequence of this visit that the important modification of the plans of the Company involved in the substitution, to a large extent, of a system of power distribution for a system of water distribution came to be adopted. The American engineers were anxious to obtain the best European advice as to the methods best suited to the local conditions. A commission was formed, consisting of Lord Kelvin, Dr. Coleman Sellers, Prof. Mascart, and Colonel Turrettini, and an invitation was given to engineers and engineering firms in Europe and America to send in competitive projects for the utilisation of the power at Niagara and its distribution to different consumers at Niagara and in Buffalo by electrical or other means. Many of the plans sent in were worked out with great care and completeness. As to the hydraulic part of the projects there was some approach to general consent as to the arrangements to be adopted, but as to the methods of distributing the power there was an extraordinary diversity. Generally the commission reported in favour of electrical distribution, with perhaps a partial use of compressed air as an auxiliary method. Generally also they reported in favour of methods of distribution by continuous currents in preference to alternating currents. Since the date at which the commission reported, the Frankfort-Lauffen experiment has been made, and in the opinion of some electrical engineers a distinct advance has been achieved in the use of alternating currents at high potential. The company has not yet decided to adopt any plan for the central stations except in a tentative way. One or more turbines of 5,000 H.P. are to be erected, and probably at first this power will be distributed to Buffalo by an alternating-current system. The cost of a steam horse-power at Buffalo is reckoned at $35 per annum. I believe the company will be able to deliver power at from $10 for large amounts and a greater price for small amounts, this price being reckoned for 24-hour days. The new industry of electric lighting has made necessary the provision of large amounts of motive-power. Electric traction similarly depends on the supply of motive-power. New chemical and metallurgical processes are being introduced which entirely depend for their commercial success on the supply of motive power at a low price. Niagara is likely to become not only a seat of large manufacturing operations of familiar types, but also the home of important new industries.

LIST OF THE ELECTRICAL PAPERS READ AT THE BRITISH ASSOCIATION.

The following is a complete list of the electrical Papers read, reports presented, and exhibits, at the recent meeting of the British Association:—

SECTION A.

Prof. H. E. J. G. du Bois.—"On Leaky Magnetic Circuits."

Dr. Dawson Turner.—"Exhibition of Experiments on the Influence of Neighbouring Electrical Discharges upon Electrical Resistance."

Prof. E. Wiedemann.—"On Electrical Discharges."

Prof. A. Schuster, F.R.S.—"On Primary and Secondary Cells in which the Electrolyte is a Gas."

Prof. W. E. Ayrton, F.R.S., and Dr. W. E. Sumpner.—"The Efficiency of Transformers."

Prof. W. E. Ayrton, F.R.S., and E. W. Smith.—"Note on the Registration of Transformers."

Profs. A. W. Reinold, F.R.S., and A. W. Rücker, F.R.S.—"On the Specific Conductivity of Thin Films."

Magnus Maclean and Alex. Galt.—"Some Experiments by a Ruhmkorff Coil."

J. Gray.—"A Contribution to the Theory of the Perfect Influence Machine."

Magnus Maclean.—"Sources of Heat generated in the Galvanic Battery."

Dr. W. Peddie.—"On the Electric Conductivity of Bismuth and Copper in Magnetic Fields."

A. A. Campbell Swinton.—"Photographs of Electrical Discharges."

J. H. Gray and T. Littlewood.—"Slow Oscillations produced on discharging Electric Condensers of great Capacity."

Rev. F. J. Smith.—"Inducto-script."

Prof. P. H. Schaute.—"On the Construction of the New Physical Laboratory, at Groningen, Holland."

Prof. J. A. Ewing, F.R.S.—"A Magnetic Curve-Tracer."

Prof. H. E. J. G. du Bois.—"On a Magnetic Balance and its Practical Use."

Dr. S. Lindeck.—"On Wire Standards of Electrical Resistance.

Dr. Kahle.—"On the Clark Cell."

W. H. Preece, F.R.S.—"On the Dielectric of Condensers."

W. H. Preece, F.R.S.—"On Earth Current Storms of 1892."

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PROF. S. P. THOMPSON, F.R.S.—"On the Physics of the Voltaic Arc."

E. H. BARTON and W. WILLIAMS.—"The Temperature Variation of the Magnetic Permeability of Magnetite."

PROF. C. G. KNOTT.—"On the Volume Effects of Magnetisation."

PROF. H. E. J. G. DU BOIS.—"Polarising Gratings."

PROF. G. F. FITZGERALD, F.R.S.—"On the Rate of Propagation of Magnetisation in Iron."

DR. J. H. GLADSTONE, F.R.S., and W. HIBBERT.—"Some notes on Electromotive Force of a Secondary Battery."

DR. JOHN KERR.—"On Dispersion in Double Refraction due to Electric Stress."

Report of the Committee on a National Physical Laboratory.

Report of the Committee on Electrolysis.

Report of the Committee on the Discharge of Electricity from Points.

Report of the Committee on Electrical Standards.

Report of the Committee on Electro-optics.

SECTION B.

PROF. CRUM BROWN, F.R.S., and Dr. J. WALKER.—"Electrolytic Synthesis."

Report of the Committee on the Influence of the Silent Discharge of Electricity on Oxygen and other Gases.

SECTION D.

PROF. G. FRITSCH.—"On the Origin of the Electric Nerves in the Torpedo Gymnotus, Mormyrus, and Malapterurus."

H. NEWMAN LAWRENCE.—"The Human Body as a Conductor of Electricity."

SECTION G.

PROF. G. FORBES, F.R.S.—"The Application of Destructors, especially to the Electric Lighting of Edinburgh."

ALEXANDER SIEMENS.—"Electric Locomotives on the City and South London Railway."

PROF. J. BLYTH.—"A New Form of Windmill for Electrical and other Purposes."

W. H. PREECE, F.R.S.—"On the Destruction of Lightning Protectors by Recent Municipal Legislation."

W. H. PREECE, F.R.S.—"Secondary Batteries at the General Post Office."

G. KAPP.—"Power Transmission by Simply Alternating Currents."

E. H. WOODS.—"A New Electrical Locomotive."

GERMAN CENTRAL STATION DATA.

The following table is compiled from one published by Herr Kittler:—

Town.	Maxim'm amperes available A (1891)	Day of maximum consumption (1891).		Ratios (1891).		Ratios. Average since station opened.	
		Amp.hrs. Q	Amperes a	$\frac{a}{A}$	$\frac{Q}{A}$	$\frac{a}{A}$	$\frac{Q}{A}$
Berlin	64,000	307,000	36,900	0·58	4·80	0·72	5·66
Hamburg	6,350	34,000	3,650	0·58	5·37	0·58	5·40
Barmen.....	3,141	7,086	1,190	0·38	2·24	0·41	2·74
Breslau	5,000	21,240	3,160	0·63	4·24	0·63	4·24
Darmstadt ...	3,736	10,410	2,260	0·60	2·79	0·55	2·92
Düsseldorf ...	5,754	18,720	2,940	0·51	3·26	0·51	3·26
Elberfeld	4,905	19,218	3,500	0·71	3·92	0·77	4·35
Hanover	5,836	20,533	3,200	0·55	3·52	0·55	3·52
Knöigsberg ...	2,918	11,500	1,870	0·64	3·94	0·64	3·94
Lübeck	2,325	7,900	1,220	0·52	3·39	0·66	4·62
Mulhouse	3,468	8,646	1,600	0·46	2·49	0·43	2 88
Stettin	3,109	13,380	1,900	0·61	4·30	0·61	4·30

The average for the twelve towns comes to $\frac{a}{A} = \cdot 59$, and $\frac{Q}{A} = 3 \cdot 99$. An examination of these figures shows that much the same conditions obtain in Germany as in this country in regard to central stations, viz., the maximum demand at any instant never exceeds 75 per cent., and rarely exceeds 60 per cent. of the maximum possible supply; the largest daily output is rarely more than equivalent to five hours of the machinery running at top load.

LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company.

JUDGMENT.

In the Court of Appeal on Wednesday, judgment was delivered by Lord Justice Lindley, Lord Justice Lopes, and Lord Justice Kay in the case of "Lane Fox v. the Kensington and Knightsbridge Electric Lighting Company."

LORD JUSTICE LINDLEY said: This is an appeal by the plaintiff against a judgment of Lord Justice A. L. Smith dismissing an action brought for the infringement by the defendants of a patent belonging to the plaintiff. As usual in such cases, the defendants denied the infringement, and denied the validity of the plaintiff's patent, on the ordinary grounds of want of subject matter, want of novelty, want of utility, insufficiency of the specification; and, in addition to these, the defendants contended that the nature of the invention as described in the provisional specification was not the same as that described in the complete specification, at any rate after it had been amended and put into its present form. Lord Justice Smith decided in the defendants' favour on the last point, but he also came to the conclusion that the invention as described could not be usefully worked; and that the directions to work it were insufficient. He, however, decided the other points in favour of the plaintiff, and held that if the patent had been valid the defendants would have infringed it. A cross notice of appeal was given by the defendants, and the whole case was argued at great length before this Court by Mr. Lane Fox in person on the one side, and by Mr. Wallace as counsel for the defendants on the other. The Court was supplied with a printed copy of the shorthand notes of the evidence in the Court below, and of the arguments of counsel on the trial of the action and of the judgment of the learned Judge. All these I have carefully read and studied since the argument in this case was closed.

The plaintiff's patent, as described in his original specification, was for "improvements in obtaining light by electricity, and in conveying, distributing, measuring, and regulating the electric current for the same, and using means or apparatus employed therein." The provisional specification was filed on October 9, 1878, and the complete specification was filed on April 9, 1879. Owing to subsequent disclaimers and amendments, which it will be necessary to examine more carefully by-and-by, the only part of the patent which has to be considered is that relating to the distribution and regulation of electric currents for purposes of lighting. In order to understand the nature of the plaintiff's invention, and the objections taken to the validity of the patent, it is necessary to ascertain what was the state of knowledge as regards electric lighting in 1878. This is by no means an easy matter; for since that time much has been learned, vast improvements have been made, and the progress has been so fast and yet so gradual and continuous, that there is great danger in supposing that what is now plain and well known was plain and well known then. The evidence given in the case shows that the following matters were well known in 1878:—(1) That electricity could be used for lighting purposes; (2) that the arc or brush light was known and in course of being perfected; (3) that incandescent lighting was foreseen as possible and probable, and that many persons were trying to discover how to effect it; (4) that electric generators and what are now called dynamos were well known; (5) that Planté's secondary batteries, capable of being charged by an electric current, and of storing electricity (*i.e.*, of remaining inert), and of giving electricity out when wanted, were well known, and had been used for lighting; (6) that the voltage of the electric current given off by such batteries could be increased or diminished by adding or removing cells; (7) that in order to obtain and maintain an electric current a complete conducting circuit was necessary; (8) that for currents of low tension the earth itself might be used for a return conductor; (9) that earth, or "an earth," was a technical expression used to denote any suitable return conductor; and (10) that any competent electrician would know that if in any particular case he could use the earth itself as a return conductor, some other return conductor would have to be provided. On the other hand, the evidence shows that in 1878 it was not known how to construct an incandescent electric lamp for any generally useful purpose. It was not known to be important for the purpose of lighting with such lamps that the current supplying them should be kept at a constant pressure of about 100 volts; nor was it known that good results for incandescent electric lighting would be obtained by using secondary batteries, such as Planté's, in conjunction with dynamos. Further, in 1878, dynamos did not work so smoothly as they do now; that some better method of regulating the action of the engines used to drive them was necessary, or at least desirable. Lastly, it was not known that for lighting large districts with incandescent lamps with electrical currents of high tension the earth could not be used as a return conductor. Such being the state of knowledge in 1878, the plaintiff claims by his patent to have done three things which were new and useful, viz. (1), he claims to have invented a lamp which would answer the purpose; (2) he claims to have invented a method of keeping the electromotive force of the current in the mains constant at about 100 volts; (3) he claims to have invented a method of better regulating the engines which drove the dynamos. The lamp has been since replaced by cheaper and better ones, and has been disclaimed. The regulator has become unnecessary by reason of improvements in engines and dynamos, and has been disclaimed, but it was a very important part of the original invention. There remains the invention for keeping the electromotive force of the current constant. This invention is the one which has to be considered in this action.

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An invention is not the same as a discovery. When Volta discovered the effect of an electric current from his battery on a frog's legs he made a great discovery, but no patentable invention. Again, a man who discovers that a known machine can produce effects which no one knew could be produced by it before may make a great and useful discovery, but if he does no more his discovery is not a patentable invention. ("Britain *v.* Hirsh," 5 Patent Cases, 232; "Harwood *v.* Great Northern Railway Company," House of Lords, 654; "Horton *v.* Mahon," 12 C.B. N.S., 437; "Saxby *v.* Gloucester Wagon Company," 7 Q B., 305.) He has added nothing but knowledge to what previously existed. A patentee must do something more: he must make some addition, not only to knowledge, but to previously known inventions, and must so use his knowledge and ingenuity as to produce a new and useful thing or result, or to produce a new and useful method of producing an old thing or result. On the one hand, the discovery that a known thing, such, for instance, as a Planté battery, can be used for a purpose for which it has never been used before, is not alone a patentable invention; but, on the other hand, the discovery how to use such a thing for such a purpose will be a patentable invention. There is novelty in the mode of using it as distinguished from novelty and purpose, or if any new appliance is necessary for using it for its new purpose, and if such mode of user or modification or appliance involves any appreciable merit. It is often extremely difficult to draw the line between patentable inventions and non-patentable discoveries, but I have endeavoured to state the distinction as I understand it, and as far as is necessary for the purposes of the present case. I have, of course, been guided by the previous decisions on the subject, and especially by "Harwood *v.* Great Northern Railway Company" (11 House of Lords, 656), which is the most instructive of them all.

I have been induced to make these observations in order to apply them to the question whether the plaintiff's invention was anything more than a discovery that Planté's cells can be usefully employed for incandescent lighting. If it is not, his invention will not be the subject matter of a patent. What, then, is the nature of his invention, as described in his original specifications? It certainly is not for the mere use of Planté's batteries in connection with dynamos. It is for the use of them "as described," which is a very different matter. Read the provisional specification, page 2, line 12, to the end; and the complete specification, page 4, line 11, to the end, omitting that part which relates to measuring. I cannot read these specifications without coming to the conclusion that the plaintiff thought he had discovered how to overcome one of the greatest difficulties in incandescent lighting. He points out that the electromotive force of the electric conducting mains should be kept constant at about 160 volts by means of dynamos and secondary batteries, used as described at various places and in conjunction with the regulator, which he says is necessary. That is his discovery, and the nature of his invention, as stated by himself. It is not put in this simple form; it is mixed up with the mode of carrying the invention out. The plaintiff not merely discovered that Planté's secondary batteries could be usefully employed for incandescent lighting, but he showed the importance of keeping the electromotive force in the mains constant at the best voltage, and he claims to have shown how practically the desired result could be obtained, which no one knew before. As regards the nature of the invention as originally described, and as regards its being the proper subject matter for a patent, my decision is in favour of the patentee, provided always that his invention proves practicable. This accords with the view taken by Lord Justice Smith. But this view of the plaintiff's invention is of no use to the plaintiff, for neither the defendants nor anyone else use this invention as it was originally described. The plaintiff now claims something very different, viz., the use of secondary batteries in conjunction with dynamos for the purpose of keeping the electromotive force constant in the mains at about 100 volts. Lord Justice Smith held this to be an invention very different from that originally described, and he also held that if this was the plaintiff's invention it would not work without modifications and precautions which the plaintiff never pointed out. I agree with him on both points, and I will take the last first. It is, I think, clear that no one had ever shown or professed to show how to produce this desired effect before 1878. Many prior patents were referred to by the counsel for the defendants to show want of novelty in the plaintiff's invention; but there is no trace in any of them of any method of keeping the electromotive force in a main constant at any particular voltage, nor was that the object of any of them. I dismiss them all with that short observation. I pass from the novelty to the utility of the alleged invention, and to the sufficiency of the specification for carrying it out. The utility of the alleged invention depends not on whether by following the directions in the complete specification all the results now necessary for commercial success can be obtained; but on whether by such directions the effects which the patentee professed to produce could be produced, and on the practical utility of these effects. Can it be said that the invention, as described in the amended specification, was in 1878 a practically useful addition to the then stock of invention? To judge of utility the directions in the amended specification must be followed, and if the result is that the object sought to be attained by the patentee can be attained, and is practically useful at the time when the patent is granted, the test of utility is satisfied. Utility is often a question of degree, and always has reference to some object. Useful for what? is a question which must be always asked. The answer must be—useful for the purposes indicated by the patentee (*see* per Tindal, L.C.J., in "Cornish *v.* Keene" (1 Webb's Patent Cases); "Edison *v.* Holland" (6 Patent Cases, 243); and "Badische Anilin und Soda Fabrik *v.* Levinstein" (12 Appeal Cases, pages 712, 719, 720). An invention may be useful as indicating the direction in which further progress is to be expected, and yet that same invention may be useless for any other purpose; useless, that is, as an invention without further developments and improvements which have not occurred to the patentee. This is, in my opinion, the real truth with respect to the plaintiff's invention, as now claimed by him. He made a distinct and important step in advance. The plaintiff was the pioneer; he showed others the road to be followed, but he did not give the traveller the information necessary to enable him to travel on it. There were difficulties to be overcome which the patentee did not foresee, and against which he naturally made no provision.

There is an enormous mass of conflicting evidence upon the possibility of obtaining practically useful results by following the directions contained in his specification. Much of the evidence adduced against the patentee merely goes to show that by following the directions in the specification you cannot produce such good results as are produced by the defendants. This is obviously wholly immaterial. But there is besides a great deal of evidence to show that an electrician of ordinary skill could not have produced any useful result in 1878 if he simply followed the directions contained in the specification as amended with such variations only as an electrician of ordinary skill would have known how to make in 1878. So much more can be done now by a Planté battery than was suspected in 1878 that I have found the greatest difficulty in coming to a conclusion on this all important question; and I much regret that we have not had the assistance of an expert in electrical science to assist us. I have studied the whole evidence with all the care I can bestow upon it, and I have come to the conclusion that the plaintiff had not in 1878 invented what he now says he had, viz., a practicable method of keeping the electromotive force in the mains constant at about 100 volts by means of secondary batteries and dynamos used simultaneously, as described. The evidence adduced by the plaintiff shows that something like his invention can be worked on a small scale, and to a limited extent, when it is not necessary to charge the mains so as to produce a high-pressure when the lamps are connected with the main. Prof. Barrett's evidence as to what he did in his own laboratory for six years shows this; and it must be borne in mind that for a time he used water pipes and the earth as a return conductor, and showed them to be sufficient. But his voltage was low; his dynamo produced a current at a tension sufficient for his lamps without the aid of secondary batteries, and he used his batteries as reservoirs rather than as regulators. Moreover, Prof. Barrett did not produce those results earlier than six or seven years ago, when much more was known about what could be done with Planté batteries than was known in 1878. The other cases in which the plaintiff endeavoured to prove that his invention had practically succeeded will be found to have involved considerable important departures from his invention as described. The installation for Lady Conyers' ball is the best case the plaintiff has; but there the batteries were taken charged, which is a very important matter. The defendants have, in my opinion, succeeded in proving that the lamps will be destroyed if, whilst they are connected with the main, the batteries are charged at a sufficient voltage to work for any useful purpose. This objection to the patent goes to the root of the plaintiff's alleged invention. The objection is said by the plaintiff to be based upon the erroneous assumption that the batteries must be charged and emptied to an extreme extent. Charging and discharging are no doubt relative terms to be understood within reasonable limits; and a workman intelligent enough to seize the idea of the patentee would perhaps know in a general way that the electromotive power could be regulated and kept approximately constant without excessive charging or discharging, and the brightness or dimness of the lamps would be his guide. But conceding this I think it proved that high charging is necessary to keep the electromotive force constant, and at anything like 100 volts; and if necessary it is not disputed that the lamps will be destroyed if the batteries are charged when the lamps are on, unless precautions against this cause of failure are taken. None, however, are indicated in the specification. I think it proved that a small variation in pressure in the main will cause a current to go into or come out of the secondary battery for a very short time. But this is not enough for practical purposes. High charging being necessary, it is in my opinion proved that the plaintiff's invention will not work without switches; and these are not mentioned in the specification. Upon this point there is much conflicting evidence, attributable in great part at all events to the ambiguity of the term "switching." It was known before Planté invented his secondary batteries that the voltage of primary batteries could be increased or diminished by increasing or diminishing the number of cells. The mechanical means of doing this is called switching; and Planté himself pointed out that the voltage of his secondary batteries could be increased or diminished by similar means. Regulation to some extent takes place without switches. It is admitted by the defendants' own witnesses that the batteries have a steadying effect for a short time; that they act as regulators to some small extent, and Prof. Barrett has produced satisfactory results in his laboratory with low voltage without switches. In Lady Conyers' case there were no switches, but there was no dynamo at work. On the other hand, the evidence convinces me that for practical lighting with an electromotive force of about 100 volts, and with dynamos and batteries and lamps all in use, switching is essential, and that no ordinary competent electrician would have known in 1878 how to keep the electromotive power in mains constant at about 100 volts without further instructions than the plaintiff gave him.

The plaintiff's claim to have invented in 1878 a practically useful method of keeping the electromotive force in the mains constant at about 100 volts whilst the dynamos are running and the batteries are being charged and the lamps are on, cannot, in my opinion, be sustained. This is the broad ground on which I think the patent, as amended, must be invalid, and this was the only ground on which Lord Justice Smith condemned it on its merits.

Having arrived at this conclusion, it is unnecessary to consider the objections taken to the specification, upon the ground that the directions about the earth were misleading, and that the direction that the cells of the batteries should have very large conducting plates was too indefinite. I have hitherto made no allusion to the plaintiff's regulator; but this was, in my opinion, an essential part of his original invention. He says in his

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original specifications that it is necessary—for what? The context shows that it was necessary to keep the electromotive force in the mains constant. This was a mistake, and the regulator and all that was said about it has been disclaimed and struck out by the amendment. But the effect of this is entirely to change the value of the invention as described in 1878, and to enlarge it, which was not permissible. (See "Gaulard and Gibbs," Patent Cases, 215.) In the original specifications the plaintiff drew a marked distinction between storing and regulating; the secondary batteries were for storing, the regulator was for regulating. It is true that storing involves of necessity a certain amount of regulation; but over and above such regulation as is necessarily incidental to storing, further regulation was said by the inventor in 1878 to be necessary for his invention. Between 1878 and 1883 he discovered that the regulator was not wanted, and that everything cou'd be done by secondary batteries as used in 1883, by which time dynamos and switching had been greatly improved. He accordingly disclaimed the regulator. I am satisfied that the plaintiff had no idea that he could do without the regulator when he obtained his patent. He learned it afterwards; and by disclaiming the regulator and amending his specification in 1883 as he did, the plaintiff essentially changed the nature of his invention for keeping the electromotive force in the mains constant. The claim to the use of the batteries as reservoirs had a definite meaning in the original specification, but it has a different and much wider meaning in the specification as amended in 1883. The plaintiff is now really claiming a patent for the mere use of Planté's batteries in conjunction with dynamos. Such a patent would not have been valid unless the patentee had done something more; he must have shown how the two were to be successfully worked together. Assuming that a patent for such an invention might have been obtained, the plaintiff's patent was not granted for any such invention. The effect, therefore, of the disclaimer and amendment made in 1883 has been to destroy the validity of the plaintiff's patent, if it ever could have been made to work. Upon this point, again, I agree with Lord Justice Smith.

It is needless to consider the question of infringement. I will only add that if plaintiff's patent could be upheld as a patent for the use of secondary batteries in combination with dynamos, then the defendants would obviously have infringed his patent. But unless his patent can be upheld to this extent no infringement has taken place. Convinced as I am that the plaintiff made a great step in advance when he suggested the application of Planté's batteries for the purposes of incandescent electric lighting, I feel bound to hold his patent invalid on the ground that it was granted for an invention very different from that which he now claims to be protected: and on the ground that it was not in 1878 useful for the main purpose for which it was invented, viz., the practical lighting of large districts; and upon the ground that his specification was insufficient to enable an electrician of ordinary competence and skill to carry it out without further experiments and invention as distinguished from more practice and increased dexterity and skill. The appeal therefore must be dismissed, with costs in the usual way.

LORD JUSTICE LOPES concurred.

LORD JUSTICE KAY: This action is brought to restrain infringement of the plaintiff's patent, and for an account of profits or damages. The patent is dated 1878, and has been amended by two disclaimers in 1882 and 1883. The case is one of some difficulty, and the difficulty arises in great measure from the fact that the patent relates to electric lighting by incandescence, and in 1878 no practical mode of doing this had been perfected. Mr. Lane Fox contemplated lamps in which the incandescent material was platinum or iridium, which was to be maintained at a luminous heat not *in vacuo*. The incandescent lamp now in use in which the material is carbon enclosed in a glass bulb exhausted of air was not brought into practical use until some years after Mr. Edison's patent in 1881. The real object of this action is to claim the exclusive right to the use of what are called accumulators in the modern system of electric lighting. I understand that accumulators are, in fact, what were originally called secondary batteries. They were invented or improved by Planté, and at the time of this patent were known as Planté's batteries. They are not batteries for the original generation of electricity; but if I rightly understand the evidence they are constructed of plates of lead partly immersed in dilute sulphuric acid, the alternate ones connected with the positive and negative poles of the battery and in the circuit with a dynamo or other generator of an electric current. When electricity is by the action of such generator passed through the battery, an alteration takes place in the bed-plates by the deposit upon their surfaces of peroxide of lead. When the generator ceases to act, if the circuit is continued there is a resolution of that peroxide, and the battery during that chemical process gives out a considerable quantity of electricity. Directly the generator ceases to act, however, the electromotive force—called otherwise the voltage or potential, lowers at first rapidly, and then much more slowly, and the current is maintained at this lower voltage for a considerable period, varying, of course, with the size of the plates in the battery, and the quantity in amperes of the charge. Although this was known before the plaintiff's patent, and Planté's batteries are accordingly mentioned in his provisional specification as "reservoirs" of electricity, the provisional specification does not indicate distinctly that they were intended in his combination to answer any other purpose. The combination which he claims that the defendants are infringing consisted of several elements: (1) A number of incandescent lamps arranged, not in series, but what is very inartistically called in parallel, that is through each of which passes not the whole current carried by the main wire, but a portion only drawn from the main wire by a small wire serving the lamp, from which it is returned also by a separate return wire; (2) the introduction into this system of several Planté batteries joined in like manner to the main wire at different points, and each having a separate junction with the return. The complete specification contains this sentence:—"In order to keep the electromotive force in the mains constant it is desirable to have, in the first place, several generating machines, also a number of reservoir batteries, as before explained." In the provisional specification the last clause of that sentence, "also a number of reservoir batteries, as before explained," did not occur. Instead, the sentence ran thus:—"Next it is necessary to have some regulator, such as that about to be described." The regulator was an electrometer, the needle of which oscillated between two metal points. When the voltage was too high it touched one, and completed a circuit which actuated a lever so as to shut off steam, and this diminished the speed of the dynamo. When the voltage got too low, the needle deflecting in the opposite direction touched another metal point, which produced the contrary effect and quickened the motion of the dynamo. This regulator is struck out by disclaimer, and now in the altered specification the only regulation is keeping the electromotive force in the mains constant, which is to be done by—(1) Several generating machines, and (2) a number of reservoir batteries. I find it impossible to make the provisional and complete specifications consistent in this respect. The provisional describes the mode of keeping the electromotive force constant, (1) several generating machines, and (2) the electrometer regulator. It does not mention the secondary batteries as useful for that purpose, but as reservoirs only. Mr. Lane Fox argued before us that their purpose was to act as a sort of buffer (to use the expression he frequently employed); and, accepting an illustration suggested by the Bench, he said their office was something like that of the air vessel in a force-pump, which arrests the pulsation of the pump, and causes the water to be delivered in a continuous stream. I am satisfied by the evidence that this would not be the effect of the secondary batteries if employed as described by his patent. He directs them to be charged from the dynamo while some lamps are in the circuit. Taking the voltage requisite for the lamps at 100, I think it is clear that the batteries, at least with any reasonable size of lead plates, could not be charged so as to be useful for this purpose with a current of less than 115 to 125 volts, which would destroy the lamps in a short time. Even if properly charged they could not practically be used to keep up the current when the dynamo was not running without an arrangement by which the number of battery cells in connection with the main wire could be altered from time to time by a system of switches. If the use of the batteries was to keep the electromotive force constant in the main wires there are two objections to this patent, each of which seems to me formidable. First, this is not contemplated by the provisional specification, which describes a different mode of effecting that purpose, and, therefore, differs essentially from the complete specification; and secondly, the mode of using the batteries described in the complete specification of this patent will not produce the effect of keeping the electromotive force constant in the main wire. The use of these batteries as reservoirs of electricity was merely using them for the purpose for which they were invented by Planté, and a patent for putting such reservoirs in connection with the main wires in a system of electric lighting involves no invention whatever, any more than using water reservoirs in connection with pipes supplying a city with water. By disclaimer the plaintiff struck out from his specification the regulation by the electrometer. As I read the provisional specification, this, and the employment of several generating machines, was the only mode of regulation which the patentee originally contemplated. But I think by regulation he did not mean keeping the electromotive force as nearly as possible constant in the various wires. The disclaimer has struck out one device for effecting this which is said both in the provisional and complete specification to be "necessary;" and it may be a question whether this is not an alteration of the invention which makes the combination now claimed essentially different. But the most serious objections in the view of this patent which I take is that it is a crude description of an invention which, as described, had no practical utility. Not one of the elements of the combination was new in itself. I am satisfied, as I have said, that the combination, as described by the patentee, could not be efficiently worked without at least two essential alterations—one, that the secondary batteries must be charged when the lamps were not in the circuit with a current of electricity of a voltage which the lamps would not bear; and, secondly, that these batteries would be practically useless unless they were worked with switches, as I have before mentioned. Without such an arrangement they could not be made to keep the electromotive force constant in the main wires. The automatic action which Lane Fox supposed would accomplish this is, I am persuaded, a mere delusion. These two essential alterations were necessary to make accumulators of use. Neither of them is contemplated by Lane Fox. Assuming that he was the first to suggest the placing of reservoir batteries in communication with the main wires in a system of electric lighting by branches from the main, his mode of doing this was practically useless, and for this reason I agree with the result at which the learned Judge has arrived. I think the patent is invalid, and that this appeal should be dismissed.

Appeal dismissed accordingly, with costs.

Northern Electric Wire and Cable Manufacturing Company (Limited) v. Fowler, Lancaster, and Co. (Limited).

In the Crown Court, Leeds, before Mr. Justice Grantham, on Monday and Tuesday last, this action was heard. The plaintiffs sought to recover £66, alleged to be due for cables, wire drums, &c., supplied. The defence was that there had been an overcharge in respect of some of the goods, and that certain allowances which should have been made for returns had not been made. The defendants also claimed £900 as damages for non-supply of electric cables within a reasonable time, whereby it was said the defendants suffered delay in completing the system of electric lighting on three battleships, and suffered by reason of not obtaining further contracts.

After a lengthy hearing his LORDSHIP, after commenting very strongly upon some of the facts given in evidence, and censuring both parties, gave a verdict for the plaintiffs for £39. 11s., and for the defendants for £58. 15s. 3d., without costs to either party.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 29, 1892.

Extensive Transmission Plant.—Although we do not hear so much about the installation of extensive plants for the transmission of power by electric means as we did six months ago, nevertheless there is going on a great deal of work in the preparation for some very elaborate installations of this character. I have it on the authority of the designing engineer of one of the large companies that he is preparing estimates for a plant for the transmission of power of 20,000 H.P. capacity. It is a fact that large installations are now becoming so common that their economy is better known to financial men than it was a few years ago, and these men are now making inquiries of the large companies for estimates on plants of from 5,000 to 10,000 and 15,000 H.P. capacity.

From Niagara Falls to Chicago.—Very little is heard now of the proposed installation of a transmission plant between Niagara Falls and Chicago. The idea of this plant of course originated with the successful operation of the Frankfort-Lauffen plant; but the distance in this case is so much greater than in the Frankfort plant that it is doubtful if any American or foreign firm cares to undertake the installation of the line, to say nothing of the experimental dynamo and motor plant.

Transformers in Long-Distance Transmission.—Foreign engineers, who, as a rule, are in favour of the use of step-down and step-up transformers in transmission of power plants, will be interested to know that there is considerable opposition to this plan among leading engineers in this country. American engineers are more in favour of the extensive use of copper in line construction rather than the expenditure of the same or even a less amount of capital in the installation of extensive transformers, which, however economical, would at best be more likely to break down, and cost more to operate and keep in repair than a good substantial copper line. American engineers do not place much confidence in the expectation that step-up and step-down transformers will come into use for plants where power is transmitted over less than ten miles, and some go so far as to express the belief that the direct method is much to be preferred for distances that do not exceed 20 miles.

The General Electric Company is rapidly carrying out the policy which has for many years prevailed in the management of the Thomson-Houston Electric Company under the direction of Mr. C. A. Coffin. The management cares very little for sentiment, and is planning to pay dividends to the stockholders rather than to make an extensive showing before the general public. The way in which expenses are being cut down is well illustrated by a step which has just been taken, which, although not expected by the stockholders of the former Edison Company, is characteristic of the management of the new Company. It is announced on good authority that the private laboratory of Mr. Edison has been quietly placed on the shelf as an expensive and unnecessary luxury, which the Company could not afford to keep up. Some 300 *employés* of Mr. Edison's laboratory who had been on the pay roll of the Edison Company have been discharged, and only enough *employés* retained to carry on what the Company consider the necessary experimental work of the laboratory directly in line with the apparatus which the Company is handling. A good authority states that the Company will save not less than $500,000 a year by this method; and the same authority states that another $500,000 has been saved by the entire abolition of what was known as the engineering and designing department of the Edison Works at Schenectady. Considering that, it is thought that it will not be very long before the stock of the General Electric Company is selling at a figure not far from 150, and that dividends will be increased to a considerable extent.

Lamp Manufacturing Companies are beginning to look with anxiety for a decision in the Edison filament patent case, although the general expectation is that it will be decided in favour of the Edison Company. It is more than probable that should the case be decided in favour of that Company, the General Electric Company will use the embarrassing position in which the Westinghouse Company will then be placed to force it to come into the combination at a very low figure, while the smaller companies will be either closed out or compelled to surrender their stock at a low estimate, depending on whether they have patents which the General Electric Company cares for; or whether, as is the case in a few instances, the smaller company holds one or two lamp patents which might later prove of value to the big Company. It is of considerable interest to know that the Sawyer-Man treating patent held by the Westinghouse Company is considered of sufficient value to warrant the taking in of the Westinghouse Company as a part of the consolidated Company.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Oldham Corporation invite tenders for the supply of switchboard instruments and connections. Specifications and drawings are to be obtained of Mr. Alex. B. W. Kennedy, 19, Little Queen-street, Westminster, S.W., and tenders must reach Mr. A. Nicholson, the Town Clerk, not later than Friday, the 2nd prox. Further particulars appear in our advertisement columns.

——— The Gas Committee of the Manchester Corporation invite tenders for the supply of an electrical crane at their station in Dickinson-street. General conditions of contract and specifications can be obtained on application (in writing only) to Mr. C. Nickson, Superintendent of the Gas Department, Town Hall; and tenders must be in by 10 a.m. on the 19th inst.

——— The Burnley Town Council invite tenders for various work required to be done in the erection of an electric lighting station in Aqueduct-street. Particulars may be obtained at the office of the Borough Surveyor; tenders must be in by the 30th inst.

——— The General Post Office invite tenders for the supply of hard-grown larch telegraph poles. Forms of tender, containing all particulars, may be obtained on application to Mr. Chas. E. Stuart, Controller of Stores, Telegraph-street, London, E.C., by whom tenders will be received until noon on the 22nd inst.

——— The Directors of the Baden State Railways invite tenders, to be delivered at Carlsruhe by September 5, for the lighting by electricity of their steamships "Kaiser Wilhelm" and "Grief." The Directors will also receive tenders until 31st October for the lighting by electricity of the central goods railway station and wharf buildings at Mannheim.

——— The Municipality of Alcañiz, Spain, invite tenders for the supply of an electric light installation for the town, and for the working rights for ten years. Particulars may be obtained from El Ayuntamiento Constitutional, Alcañiz, and tenders are to be in by the 30th inst.

——— The Municipality of Villena, Spain, invite tenders for the supply of an electric light installation for the town, with sole concession for fifty years. Particulars are to be obtained from El Ayuntamiento Constitutional, Villena, and tenders are to be in by Sept. 6.

TENDERS ACCEPTED.—The following tenders have been accepted by the Glasgow Corporation for the street lighting of the city:—

Engines...	Messrs. Easton and Anderson (Limited)	£1,108	0	0
Dynamos.	Brush Electrical Engineering Co. (Ltd.)	1,510	0	0
Arc Lamps	Ditto.	ditto.	7	13	8

——— The tender of Messrs. Cox-Walkers has been accepted for the supply of electrical tell-tale clocks for the Derby Borough Asylum, at £71.

TENDERS RECEIVED.—The following is the complete list of tenders for the supply of condensers for the electric light installation at Bristol:—

John Kirkaldy (Limited)	£6,042
Pulsometer Engineering Company (Limited)	5,965
Messrs. G. E. Belliss and Co.	4,960
Brush Electrical Engineering Company (Limited)	3,977
Woodhouse and Rawson United (Limited)	3,752

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Part of the work specified in the latter tender, amounting to £50, was afterwards withdrawn, reducing the tender to £3,702, at which it was accepted, as previously announced.

MESSRS. JOHNSON AND PHILLIPS.—This firm have entered into a contract with the Chatham, Rochester, and District Electric Lighting Company (Limited), for the laying of underground mains at Chatham on the Brooks' oil system.

THE ELECTRIC LIGHT IN SPAIN.—The Allgemeine Elektricitäts Gesellschaft have obtained the concession for the installation of 800 16-c.p. lamps at the Casas Consistoriales at Barcelona, and for the erection of a central station at Oviedo; they are also making progress with the central station at Santander. The lowest tenders for establishing a central station at Tolosa were from MM. Manterola, and Planas, Flaquer and Co. The central station at Alicante, installed by Messrs. Siemens and Halske, has just commenced working.

ACCRINGTON.—At the last meeting of the Town Council a motion was adopted, calling upon the Legal and Parliamentary Committee to submit to the next meeting a full report with respect to the establishment of the electric light. In the course of the discussion it was stated that a number of local gentlemen were prepared to take up the matter of lighting the town, and the Mayor stated that the Council were only waiting for the erection of destructors in order to get power.

BILSTON.—The new Market Hall, which was opened on the 9th inst., is dependent upon electricity for lighting. The interior is lighted by eight 2,000 c.p. arc lights, and by 74 incandescent lamps of 16 c.p. in the closed stalls, offices, &c., and the exterior by two 2,000 c.p. arc lamps. The whole of the plant has been supplied and erected by the Brush Electrical Engineering Company (Limited).

BISHOP STORTFORD.—The Provisional Order granted to the Bishop Stortford Electric Light and Steam Laundry Company (Limited) has been revoked by the Board of Trade.

CARDIFF.—At the meeting of the Lighting Committee of the Corporation on Thursday (last week), Mr. Massey was appointed to carry out the electric light installation, to prepare plans, specifications and estimates, and generally supervise the work.

HECKMONDWIKE.—At the next meeting of the Local Board a resolution will be proposed to authorise the construction of the necessary plant for lighting Heckmondwike by electricity.

WALSALL.—At the last meeting of the Town Council the General Purposes Committee announced that 28 tenders had been received for lighting part of the borough by electricity, the tenders ranging from £6,712 to £22,733. The Electric Lighting Sub-Committee had been authorised to visit several towns in order to gather information respecting the systems of lighting adopted, and the success, or otherwise, of the installations.

WATERFORD.—The Corporation, having failed to come to terms with the City of Waterford Electric Supply Company (Limited) and with the Gas Company, have decided to light the city by oil lamps.

UNITED ASBESTOS COMPANY (LIMITED).—The Lords of the Admiralty have again awarded this Company the contract for the supply of all asbestos goods required in the Royal Navy during the ensuing twelve months, the principal articles being "Victor" block packing, "Victor" metallic packing, and hard-spun yarn packing for glands; "Victor" metallic sheeting, tape, rings, ovals, &c., for steam and hydraulic joints; asbestos millboard, asbestos tape, covering for steam pipes, &c.

EXHIBITION.—At the forthcoming Exhibition to be held in connection with the Royal Cornwall Polytechnic Society a feature is to be made of the application of electricity to the practical development of Cornish mining and quarrying, in lighting, pumping, hauling and ventilating. The Society offers a special medal for an electric rock drill.

ELECTRICAL TARGETS.—A Mr. W. H. Elton, of Exmouth, has recently taken out a patent for a new target to be worked by means of the electric current.

Mr. T. HARDING CHURTON.—Mr. Churton has secured the contract for lighting by electricity the new Police Buildings, including two Courts now being built, at South Shields.

MESSRS. EVANS, STEWART, PALMER AND CO.—This firm have secured the contract for an electric light installation at Messrs. Westley Richards and Co.'s premises, New Bond-street, W.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.—The tenth annual edition of the above well-known annual is on sale, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (a few countries excepted), post free, 8s. 10d. A digest of the contents will be sent on application.

COMPANIES' MEETINGS & REPORTS.

City and South London Railway Company.

The ordinary general meeting of this Company was held on the 5th inst., at Winchester House, Old Broad-street; Mr. C. G. Mott in the chair.

The SECRETARY (Mr. W. F. Knight) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, I presume that, as you have all had a copy of the report, I may assume that you will take it as read. If so, it becomes my duty to move:

"That the report and accounts as presented to the meeting be received and adopted."

It is satisfactory that during the past half-year the steady increase of traffic has continued, and that the position of the Company has decidedly improved. In the first place, the number of passengers has increased from 2,412,000 in 1890 to 2,813,000 in the last half-year. That shows an increase of about 400,000 passengers; but in addition to that we have, in the past half-year, the season ticket-holders, which are estimated to amount to 100,000 additional. Therefore, in round numbers, we may say that there has been an increase during the half-year of about half a million of passengers over the corresponding period last year. When you consider that last year was the first half-year of the opening of the line, and that there was naturally a very large rush of people who came to see the line simply from curiosity, and not from any intention to use it regularly, and also that during that half-year we had the large omnibus strike in London, which added to the receipts of the Company at the time, it is satisfactory to think that we have not only carried the half million additional passengers, but that we have carried them in excess of those artificial sources of receipts. Now, the progress of the line is not simply in connection with the increase of the passengers. We have increased receipts from other sources in the shape of rents and other small items, and we have the satisfactory fact that our expenses have decreased. The percentage of expenses in the first half-year amounted to 79 per cent. of the receipts, in the second half-year they were reduced to 76 per cent., and in the half-year just closed they have been further reduced to 70 per cent. I hope that figure will go on steadily decreasing half-year by half-year until we come down to a really satisfactory figure. Of course, in the early history of a small concern like this, the percentage of expenses must always be great, but as the traffic develops that percentage steadily decreases, as has been the case in the past history of almost all our English railways. You therefore see that during the three half-years of which we have had experience we have steadily increased our receipts half-year by half-year, and have steadily decreased our expenditure. In the first half-year the net earnings of the line were sufficient to pay its expenses and the whole of our debenture interest; in the second half-year they were sufficient to pay the expenses, the debenture interest, the full dividend on the preference shares, and to carry forward a moderate balance; in the last half-year they have been sufficient to pay the expenses, debenture interest, the full dividend on the preferred shares, half per cent. dividend on the ordinary share capital, and to carry forward a balance larger than we brought into the half-year. These are all symptoms of a very steady and satisfactory progress. I am sure we could all wish that that progress was more rapid, but at the same time we must recollect that all sound businesses have to be worked up by slow degrees, hard work, and good management. When, however, they have been so worked up they are far more permanent and solid than those successes which are achieved rapidly, and which too often rapidly diminish afterwards in the same way. I believe there is no better and no more permanent mode in which capital could be invested in this country than in a purely passenger line in the metropolis, if the cost of that line is commensurate with the probable income to be derived from it. I believe our costs in this line will be found in the future to be so commensurate, and that the future dividends, when they have steadily accumulated, as I believe they will, from half-year to half-year, will arrive at a figure that will satisfy all our shareholders. I will now call your attention to the accounts of the half-year in more detail. As regards the capital, we have issued £30,904 in preference shares and £3,300 in debentures, making a total of £84,204. We have received for surplus land sold £5.800, making the total receipts on capital account £40,004. That has cleared off a great many of the liabilities which were standing at the debit of capital account; but, as you will see, there is still a debt of £22,000 remaining there. We hope that in the course of this half-year we may be able to clear all that off, especially that portion which is now bearing interest. If you turn to the revenue account No. 9 you will see that the receipts from passengers and parcels amount to £20,940, and from rents and other small sources of income £580, making the total receipts £21,520 in the half year, against £19,637 in the corresponding half of last year, or an increase of £1,833. On the other hand, the expenses of maintenance have increased by the sum of £52, the locomotive expenses have decreased by £552, the carriage and waggon repairs have increased by £63, the traffic expenses have decreased by £484, the general charges have increased by £78, the law charges have increased by £35, the rates and taxes have increased by £250, and compensations by £134, making a total net decrease of £424. The result of the half-year's working is that there is a profit of £6,422 11s. 6d.,

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against £4,116 in the corresponding half-year. This profit, added to £850 brought forward, in addition to the bankers' and general interest account, makes an available balance of £7,348. The debentures absorb £4,317, leaving £3,031 available for dividend. After paying the full dividend of 5 per cent. on the preference shares and ½ per cent. on the ordinary stock there will remain a balance of £983 to carry forward in place of the sum of £850 brought into the account of the previous half year. The amount to the credit of the profit and loss account would have been sufficient to pay a dividend of ¾ per cent. instead of ½ per cent., but we thought it much more in the interest of this Company that we should carry forward a larger balance and altogether be in a stronger financial position rather than pay the last penny comparatively that we had in the exchequer. One of the most interesting features in these accounts is always the question of our locomotive expenses. We still adhere to the word "locomotive" expenses, although they are not like the old locomotives. However, they are locomotives, though the force is electricity. In the first half-year our expenses were 9d. per train mile; in the second half-year they were reduced to 7·9d. per train mile; and this half-year, although there is no increase in the train mileage, the expenses are reduced to 7·7d. per train mile. In comparing these figures with those of an ordinary steam railway, you must, as I pointed out to you last half-year, recollect that we have, in addition to the work of an ordinary railway, the lifts and the hydraulic apparatus for taking the passengers to and from the surface down to the train. That makes a very considerable item in the cost of the working of our railway, and although it does not affect the locomotive expenses, it affects our general expenses to a considerable extent. But still, with all that, we are able, I think, to compare favourably upon all points with the ordinary steam railway in this country. As I told you, the locomotive expenses are 7·7d. per train mile. The ordinary locomotive expenses of the large English railways, when they get their coal at the pit's mouth without any carriage upon it, come out at the present moment at about 9d., or a trifle over, per train mile, Where they have to pay carriage upon it, as in the case of the lines South of the Thames, where there are no collieries on the lines, it is increased to 10d. or 10½d. per train mile. Of course, in our case we have not only to pay the carriage of the coal from the colliery, but we have also to pay the carriage from the station to the depôt. This increases the cost of our coal, which is a considerable item in the locomotive charges, considerably above that of any of the other railways; but, notwithstanding all these additional charges, you see that we stand at 7·7d. against 9d. to 10½d. per train mile. Of course, on the other side, our steam friends will tell us that our trains are not capable of carrying so much traffic. It is perfectly true; but, at the same time we are capable of carrying a very large traffic, and our number of passengers per train is slowly and steadily augmenting by every train we run. The average number in the first half-year was 45, in the next 46, and in the third 47 per train run. The question of fares is rather an interesting one. You remember we began with a uniform fare, which we found it necessary and expedient to alter from time to time to suit the exigencies of the traffic. The result was that in the first half-year, before we altered it to any extent, we received 1·90d. for each passenger; in the next half-year that was reduced to 1·70d. per passenger, and in the last half-year there has been a slight increase, it is 1·73d. per passenger. As far as we can judge, the result of the alterations has been satisfactory, because although we are actually earning less per passenger than we did in the corresponding period of last year, we have got a considerable increase in the total receipts. Now we will turn to the report. This being the only installation of the kind in this country, if not in the world, naturally there has been a great deal of interest to see our generating station, and in what way the power is produced. That was somewhat inconvenient to us because it interfered with the people employed at the works. We thought it, therefore, better to put up a small gallery in the engine house apart from the people employed, and to allow the public to have access to that gallery, where they could see the whole of our engines at work on payment of a small sum. I am glad to say that that has been approved generally, and that we have a steady number of people every day visiting that gallery, and adding something to the funds of the Company. Paragraph 6 of the report deals with the Joint Committee of both Houses of Parliament that was appointed to consider and report upon the best method of dealing with the various electric and cable schemes in the metropolis, proposed last Session for the sanction of Parliament. That Committee reported most favourably as regards those schemes, both as to construction and as to their working by electricity, and they have suggested that in future it would be desirable to give to any schemes easements under property where they did not do any damage at a small cost without the necessity, as we have had to do hitherto, of following the line of the streets. No doubt if this is approved by Parliament and carried out it will give much more direct and better lines than would otherwise be constructed, and diminish the cost of the extension of lines of this kind. Six years ago to-day no steps had been taken even to start the construction of this line. It is a little more than five years ago since the idea first entered my mind that we might work this railway by electricity in place of the cable system for which it was originally intended, and it seems extraordinary that in that short space of time such an entire revolution should have taken place in the views of people travelling in the metropolis that in five years' time we have applications for numbers of railways in the metropolis, and, strange to say, all of them proposed to be worked by electricity. Well, gentlemen, if the shareholders have not yet got an adequate return financially for their money, they at all events have the satisfaction of knowing that they have inaugurated a new system of locomotion, which is destined, I believe, to have a far reaching expansion and add to the comfort and prosperity of the inhabitants of this country very largely. You remember we introduced a Bill for extending our line to Islington and getting rid of the inclines under the river. That Bill was introduced into Parliament with the other Bills, but owing to the dissolution only two of these were actually passed. A Special Act was passed by which these Bills will not suffer through the dissolution, for they will be taken up this Session now at the stage they were left in. I do not, however, suppose anything further will be done with them until the early part of next year. During the past half-year we have been carefully consolidating our machinery at the generating station. We have got the new engines and the new dynamo at work, and we are now in a position to meet every possible contingency that is likely to happen on this line, and, further than that, to work a very large extension of the line without any material addition to our plant. We want as far as possible to meet the growing traffic by additional trains, but, as I have explained to you before, one of our difficulties is the want of siding accommodation. We had hoped to have gone on with that work during the past half-year, but it was delayed for various reasons. We hope within a few weeks now to start those works and sidings, which, when completed, will be of very great advantage to the working of the line. The next question which arises on paragraph 9 of the report is with reference to the debentures. Our debentures were first issued as terminable debentures. We felt at the time we issued them that it would be wrong to burden this line with a permanent 5 per cent., and I think we were wise in that decision. We therefore issued them for periods varying from five to ten years, and some of them will become due in the course of the next year. We propose to ask your sanction now for the creation of permanent debenture stock. Our idea is to issue that stock at the same rate as most of the companies have issued theirs; that is, as a Four per Cent. Stock, but of course the price of that stock at the time of its issue will determine the rate of interest which you will actually pay. We shall do our best to get it issued on the very best terms as regards premium, and we think it probable that a good many of the existing debenture-holders may, in view of the probability of that stock rising to a considerable premium, be disposed to convert their debentures upon terms to be arranged before they expire. In any case we shall be in a position to pay those off and supplement them with the debenture stock, the interest upon which will be not more than 4 per cent., and we hope something like 3½ per cent. or perhaps less. If the interest is reduced to 4 per cent. we shall save some £2,000 a year, or even £2,500, which is an important item in a small concern of this kind. After referring with great regret to the death of Mr. Kitson, a late auditor, he continued: I do not know that I have anything further to say beyond the fact that I look forward personally with great satisfaction and hope to the future of this line. I think if we all work together we shall be able to make it one of the most satisfactory railways, both financially and for comfort and convenience of the public that has ever been carried out in this country. The line as a Metropolitan line is certainly even at the present time unequalled. Its trains are run with great punctuality, at short intervals and in an atmosphere that is pure. The temperature is equable, and it is cool in summer and warm in winter. Our railway avoids all the fatigues of going up and down long flights of stairs, as in the case of most of the other Metropolitan railways, and altogether its comforts and conveniences are very great, while in the future they will, I believe, be very much greater, as gradually, by degrees, we improve all the small details of its workings. Our first endeavour naturally was to get rid of the frequent breakdowns that interfered very much with the traffic. I am happy to say they are now events of very rare occurrence, and I hope the time will come when they will be almost absolutely unheard of.

Mr. SAMPSON HANBURY seconded the resolution.

A short discussion followed, and the Board were asked what steps they proposed to take to develop the traffic, it being suggested that it was practically only in this direction that an improvement in the position of the Company could be looked for, the working expenses having been already brought to about as low a point as possible. The importance of running the trains at more frequent intervals was also advocated. The traffic existed, but it was pointed out that it could only be carried at certain hours.

The CHAIRMAN, in reply, stated that no question had absorbed the attention of the Directors so much as that connected with increasing the carrying capacity of the railway. A very considerable addition to the accommodation of the line had been given, but as long as they had been subject to frequent breakdowns, it was absolutely necessary that they should not attempt to carry more traffic than they could rightly deal with. It was of no use to increase the number of the trains only to augment the number of the stoppages. They had increased the number of the trains at certain hours of the day, when the traffic was busiest, and had reduced them at those periods when the demand for accommodation was less. The consequence was that, although the train mileage remained very much the same, the actual accommodation during the busy hours of the day had been very much increased. The one particular point to which they must direct their attention was giving the accommodation that was required, and they were now running more trains than ever. The shareholders had given the Board permission to deposit a Bill to get rid of the inclines in the river and to extend the railway into the City. He believed that if the Bill were carried through the Company would derive very great benefit. It would enable them to give such a service of trains as would command a very large increase of traffic, and the Company would be able to give this service at a very small additional expenditure. The overcrowding of the trains in the morning and evening, to which reference had been made, was not exceptional in the case of this Company; it was a feature in all trains coming into London from the suburbs.

The motion was then unanimously adopted, and the dividends on the preference and ordinary shares were afterwards declared, Mr. James L. Oliver being subsequently appointed an auditor in place of the late Major Kitson.

Resolutions were afterwards passed on the motion of the CHAIRMAN, authorising the creation and issue of the debenture stock and preference shares, as mentioned; and the meeting closed with a cordial vote of thanks to the Chairman, Directors, and staff of the Company.

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Halifax and Bermuda Cable Company (Limited).

The third annual meeting of the shareholders was held on Monday, when the Directors' report and accounts were unanimously adopted, and the auditors were re-elected.

The following is the report of the Directors:—

The result of the working for the year ended June 30, 1892, is a profit of of £1,261. 14s. 2d., to which has to be added the balance brought forward from last year of £420. 5s. 5d., making the sum now to the credit of revenue £1,681. 19s. 7d. The cable receipts in the past year were £3,915. 13s. 3d., as compared with £4,018. 9s. 4d. in the preceding year. Notwithstanding this slight decrease the Directors regard the result as quite satisfactory, as in 1890-1 there were exceptional sources of traffic. At the same time the Directors have been able to effect further economies, so that the working expenses as shown in abstracts A. and B. are £609. 10s. 3d. below the totals of the previous year.

It is subject for congratulation that all the outstanding difficulties in connection with the foundation of the Company have been brought to a satisfactory conclusion. The claims of the Construction Company have been discharged, all open matters with the International Cable Company, (Limited), have been finally adjusted, and the very heavy legal charges have been met. The result of these adjustments is that £10,153. 16s. 10d. has been expended beyond the outlays chargeable to capital account. This has in part been met out of revenue account, but, to the extent of £6,000, money has been provided on advantageous conditions by the new friends of the Company.

The Company's cable has throughout the year worked with complete efficiency, and its present electrical condition is excellent.

Under the Articles of Association the two senior Directors should retire. These are Sir Alexander Armstrong, K.C.B., and L. H. Isaacs, Esq., but these gentlemen do not seek re-election, and on the ground of economy it is not proposed to at present fill the vacancies thus created. The auditors, Messrs. Gribbon, Ingram and Holroyd, retire in accordance with the Articles of Association, and they offer themselves for re-election.

Croydon Tramways Company.

At the ordinary general meeting of this Company on Tuesday, Mr. W. J. Carruthers-Wain in the chair, the report presented by the Directors stated that the experiment in connection with electric traction had given satisfactory results. They had earned £167 on 3,323 miles run, the payment to the Electric Tramcar Syndicate therefore being £81, and the number of passengers carried thereon had been 25,649.

In the course of his remarks in moving the adoption of the report, the CHAIRMAN reminded the shareholders that at the last meeting reference was made to the arrangement which had been entered into with the Electric Tramcar Syndicate. The arrangement was on a principle which he very much liked—namely, "Heads, I win; tails, I do not lose." They made a contract by which the Syndicate was to run a certain number of cars on the Company's line for a fixed figure per mile run. The result had been most satisfactory to the Company, and the Directors had found, as most tramway companies did, that the greater the facilities they gave to the public the greater their own advantage was. The new traction seemed to increase the traffic, because the public were first of all given a novelty, and then when they got tired of the novelty they found that this particular means of traction in itself was much more advantageous in enabling them to get about their work or pleasure than the old plan. He was very sorry that, from circumstances with which their Company had nothing to do, the Electric Tramcar Syndicate was not at present working the cars, but they hoped to be able to do so again, and it would be then for the Directors to see if another arrangement could not be made with them. He would like to see the whole of their system worked by electricity. In answer to questions he stated that the Syndicate was undergoing a process of domestic reconstruction, and he had not at present received a definite proposal from them. He had hoped to have received from them a suggestion which would have enabled him to give some satisfactory information to the shareholders on the point, but at the present moment the arrangements of the syndicate were not completed.

Cuba Submarine Telegraph Company (Limited).

The following is the report of the Directors to be presented at the forty-second ordinary general meeting of shareholders, to be held at 58, Old Broad street, E.C., on the 17th inst, at 12 noon:—

The gross receipts for the half-year ended June 30th last (including the balance brought from last account) amount to £24,537. 11s. 6d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable) to £7,311. 6s. 5d., leaving a sum of £17,226. 5s. 1d. to the credit of revenue account.

There have been throughout the half-year no interruptions of any of the cables, and, therefore, no repairs have been required, so that the sum of £7,000 has become available for, and has been transferred to, the reserve fund.

The dividend on the Preference Shares will absorb £3,000, and leave £7,226. 5s. 1d., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax, the balance, £826. 5s. 1d., being carried forward to the current half-year's account.

By the decease in February last of Mr. Neil Bannatyne, the Company has lost the services of one of its first Directors, and one who was very active in its interests. On receiving an intimation from Mr. Keith—who had been Engineer and General Superintendent of the Company in Cuba for over fifteen years—that he desired to retire and remain in England, the Directors availed themselves of the opportunity to retain his valuable aid by electing him to the vacant seat at the Board. An arrangement has also been made to secure his services in the supervision and repair of the cables, upon terms both advantageous to the Company and agreeable to him. These terms will be submitted to the proprietors at the meeting.

The Company's suit against the Spanish Government at Madrid is progressing.

The Director who retires from the Board at this time is Mr. Charles W. Parish, who, being eligible, offers himself for re-election. Mr. John Gane, the auditor, also retires, and offers himself for re-election.

Telephone Company of Ireland (Limited).

The following is the Directors' report to be presented at the ordinary general meeting to be held at the offices of the Company, Dublin, on Thursday next, the 18th inst., at 12 noon:—

The Directors present their report and statement of accounts for the year ended December 31, 1891. A supplementary statement for the half-year ended June 30, 1892, is also presented, pursuant to Clause 56 of the Articles of Association, which requires that the accounts shall be made up to a date not more than four months before the annual meeting.

The Directors regret the delay that has occurred in the issue of the report, but the expiry of the two master patents in December, 1890, and July, 1891, rendered it desirable that all outstanding questions and accounts between this Company and the parent Company should, so far as possible, be finally disposed of, and that the accounts should be certified by the auditors of both Companies before being presented to the shareholders. Save as to a sum of £395. 18s. 5d., the accounts between the two Companies are now agreed to December 31, 1891, and are duly certified. In connection with this sum of £395. 18s. 5d., it should be explained that the parent Company claims to be entitled to royalty in respect of a third patent relative to the transmitters, expiring in January, 1893, and also to a rental for the telephone receivers, the patent for which expired in December, 1890. No agreement has yet been come to as to the correct amount to be allowed, but no doubt a settlement, satisfactory to both companies, will be arrived at, and failing such settlement the matter will be submitted to arbitration, in accordance with the terms of the licence. It is expected, however, that the total claim under these heads for the years 1891 and 1892, and until the date of the expiration of the third patent, January 30, 1893 (when all royalties other than those to the Post Office cease to be payable), will not exceed £650. On the expiration of the last patent, in respect of which the parent company claims royalty upon the instruments till January, 1893, it may become necessary to purchase from the National Company the whole of the telephones and transmitters now in use.

The business of the Company continues to show a steady development. The number of wires, exchange and private, under rental upon December 31, 1890, was 1,473. On December 31, 1891, the number was 1,538, being an increase of 65 for the year, notwithstanding the great interruption caused by the severe snow-storm of November, 1890, which paralysed the Company's business in Dublin during the early months of the year 1891. The increase in the number of the subscribers still continues, and, coupled with the reduced amount payable for instrument royalties, cannot fail to have a favourable effect upon the revenue for the current year, and a still more favourable effect in the ensuing year, when the instrument royalties will altogether cease.

It has been considered prudent to write off from the revenue of the year the whole of the expenses (£1,262. 3s, 2d.) connected with the issue of the debentures, and also the whole of the allowances (£672. 4s. 8d.) made to the Company's subscribers during the period when the system was under repair after the damage caused by the snow-storm in November, 1890, and also to write off on account of bad and doubtful debts a larger amount than usual, namely—£368. 11s. 10d., as compared with £181. 8s. 7d. for the previous year. Were it not for these very exceptional deductions the balance of gross revenue transferred to net revenue account would have been £5,821. 10s. 6d., instead of £3,699. 19s. 5d., as against £4,646. 14s. 11d. for the year ended December 31, 1890.

Out of the proceeds (£10,995) of the issue of £12,100 debentures made last year, a sum of £5,000 was paid to the parent Company on account of royalties and arrears. Of the balance (£5,995), £4,000 is invested in Dublin Corporation Three and a-Quarter per Cent. Stock. All expenditure upon capital account during the year, including the cost of erecting the trunk line to Belfast, has thus been practically borne by revenue.

For the information of the shareholders the Directors annexed to the report a copy of the Treasury minute upon the Government proposals for the development of the telephone system in the United Kingdom. The Bill to give effect to these proposals has received the Royal assent. The shareholders will perceive, from a careful perusal of the minute, that a new and important development of the Company's business is imminent, and it may become desirable for the Company either to acquire from the National Company their business in Ulster, or to amalgamate with that Company, the Directors being of opinion that the telephone business of Ireland would be better developed if placed under one control and management. All the telephone companies, subsidiary to the parent company, have now, with the exception of this Company, been absorbed by the National Company. In the event of an amalgamation being ultimately decided upon as preferable to a separate company for Ireland, the Directors will endeavour to effect it upon such terms as shall be just alike to this Company as to the National Company. The Post Office Department is authorised under the provisions of the Bill, to purchase from the telephone companies all trunk lines erected by them, and in these circumstances the Directors expect that the outlay under this head, which has

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been considerable and largely made out of revenue, will be recouped, and the revenue account thus placed on a satisfactory footing.

Pending a final settlement with the National Company on the expiration of the patents, and a possible readjustment of the relations of this Company with them, and having regard to the probability of capital being immediately needed to meet developments, the Directors consider it prudent to keep a substantial cash balance available. The Directors do not, therefore, propose to pay the preference dividend, or any dividend on the ordinary shares at present, but the preference dividend being cumulative its payment is only postponed.

The balance standing to the credit of the net revenue account, as upon December 31, 1891, including the balance brought from last account, amounts to £5,362. 10s. 11d., which the Directors propose to allocate as follows:—To the credit of the reserve fund, £369. 19s. 10d. (being 10 per cent. of the net profits of the year), carrying forward the balance of £4,992 11s. 1d. to credit of the current year. An examination of the supplementary accounts to June 30, 1892, will show that the balance to credit of net revenue at that date is sufficient, not only to pay the whole of the preference dividend, but leave a substantial sum for division amongst the ordinary shareholders.

In conformity with the Articles of Association, one of the Directors, Mr. Arthur Dudgeon, retires at this meeting, but is eligible for re-election. The auditor, Mr. John M. Kean, also retires at this meeting, but is eligible for re-election.

Liverpool Overhead Railway Company.

The following is the report of the Directors, to be submitted to the eighth half-yearly general meeting of the shareholders to be held at the Law Association Rooms, 14, Cook-street, Liverpool, on Tuesday next, the 16th inst., at 3 p.m.:—

Your Directors have to report that fair progress has been made during the past six months with the construction of the railway, and only 61 spans of the main structure are now required to complete. The permanent way is laid as far as the viaduct is finished. The electrical generating station is far advanced, and the engines are in course of erection. It is hoped that the railway will be completed in October.

The amount expended in construction during the past six months is £105,368. 16s. 8d. The balance to the credit of revenue account at the end of last half-year was £913. 7s. 11d., to this must be added receipts for interest and transfer fees £358. 11s. 8d., and after deducting interest on amount paid in advance of calls £60. 11s. 1d., and administration expenses £491. 7s. 1d., a balance is left to the credit of net revenue account of £720. 1s. 5d.

Your Directors have obtained an Act of Parliament providing *inter alia* for an extension of time for completing the railway, and authorising the construction of certain extensions at the north and south ends of the railway.

NEW COMPANIES, STATUTORY RETURNS, &c.

CAPON, HEATON AND CO. (LIMITED).—This Company was registered on the 5th inst., with a capital of £20,000, in £10 shares, to carry on the business of manufacturers of and dealers in india-rubber, gutta-percha, and other elastic substances, at Lifford's Mill, King's Norton, Worcestershire.

JONAS AND COLVER (LIMITED).—This Company was registered on August 6th, with a capital of £125,000, in £50 shares, to carry on the business of steel manufacturers and merchants, mechanical and electrical engineers, iron founders, &c., carried on by Joseph Jonas, at the Continental Steel Works, Attercliffe, Sheffield.

COLVER BROTHERS (LIMITED).—This Company was registered on August 6th, with a capital of £20,000, in £50 shares, to carry on the business of steel manufacturers, mechanical and electrical engineers, wire drawers, &c., at Pilot Works, Sheffield.

HOVE ELECTRIC LIGHTING COMPANY (LIMITED).—This Company was registered on August 4th, with a capital of £40,000, in £5 shares. The objects are to enter into and carry into effect agreements with the Hove Commissioners and Messrs. Crompton and Co. (Limited) to carry on the business of an electric lighting company in all its branches, within the district of the Hove Commissioners and elsewhere; to construct, lay down, establish, and carry out all necessary cables, wires, lines, accumulators, lamps, and works; and to carry on the business of electricians, mechanical and electrical engineers, iron, brass, and metal founders, suppliers of electricity for the purposes of light, heat, power, or otherwise, and of manufacturers of and dealers in all apparatus and things required for, or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The subscribers are:—

	Shares.
Harold A. Hoare, Lloyd's, E.C.	1
Colonel Alexander J. Filgate, 106, Jermyn-street, S.W.	1
Colonel Henry Wood, 95, Thorpe-road, Norwich	1
Carleton F. Tufnell, Lloyd's, E.C.	1
R. E. B. Crompton, Mansion House-buildings, E.C.	1
J. F. Albright, Mansion House-buildings, E.C.	1
Francis R. Reeves, Little Heath, Potter's Bar	1

The number of Directors is not to be less than three, nor more than five, the first to be nominated by the above-named signatories. Qualification, £500. Registered office: Mansion House-buildings, London, E.C.

LYNCH AND CO. (LIMITED).—This Company was registered on August 4th, with a capital of £25,000, in £1 shares, to carry on the business of manufacturers of electrical, chemical, photographic, surgical and scientific instruments and apparatus, at 192, Aldersgate-street, E.C.

UNITED ELECTRIC SEWAGE AND CHEMICAL SYNDICATE (LIMITED.)—This Company was registered on August 5th, with a capital of £5,000, in £1 shares. The objects are to acquire, work, develop, exercise and carry out the English, foreign and colonial rights of W. Walker, electrical engineer, of 132, Adelaide road, London, N.W., for and in his invention for which letters patent have been applied for (No. 14,039 of 1892), for "An improved process and apparatus for the purification of sewage and the production of alkalies, chlorine, ferric chloride and electric energy, and all improvements thereunder;" to carry on the business of electricians, suppliers of electricity, sewage engineers, manufacturers of chemicals for the purification of sewage, and manufacturers of and dealers in electrical and scientific apparatus.

CHILI TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to July 22nd, has been filed. The nominal capital is £250,000, in £5 shares; 40,000 of these have been taken up, the full amounts called, and all calls (£200,000) paid.

EASTBOURNE ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to July 4, 1892, has been filed. The Company was registered on February 15, 1882, with a capital of £50,000, in £10 shares. 1,017 ordinary and 47 deferred shares have been taken up, and the full amount and all calls (£10,570) paid.

ELECTRIC TRAMCAR SYNDICATE (LIMITED).—By a resolution passed on July 11th, and confirmed on July 27th, it was decided to wind up the Company voluntarily.

KENSINGTON COURT ELECTRIC LIGHTING COMPANY (LIMITED).—A resolution was passed and confirmed at meetings held on July 21st and August 5th, that the Company be wound up voluntarily, and that Mr. R. S. Erskine be the liquidator.

MANCHESTER EDISON-SWAN COMPANY (LIMITED).—The annual return of the above-named Company, made up to July 18, 1892, has been filed. The nominal capital is £550,000, divided into 50,000 "A" shares of £9 each and 10,000 "B" shares of £10 each. 20,000 "A" and 10,000 "B" shares have been taken up, £1 per share called on the former and the full amount on the latter class of shares, resulting in the payment of the full amount, viz., £120,000.

SHEFFIELD TELEPHONE, EXCHANGE, AND ELECTRIC LIGHT COMPANY (LIMITED).—A resolution was passed on July 18th, and confirmed on August 2nd:—"That it is expedient to reconstruct the Company, and accordingly that the Company be wound up; and that T. G. Shuttleworth, Sheffield, C.A., and Wm. Johnson, Sheffield, the secretary, be liquidators."

TELEGRAPH MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, made up to July 29th, has been filed. The Company was registered on November 20, 1886, with a capital of £25,000, in £10 shares; and by special resolution, passed May 22, 1888, and confirmed June 7, 1888, the capital was raised to £50,000 by the creation of 2,500 new shares of £10 each. At the time of making up, 2,800 shares were taken up, of which 646 had been issued as fully paid. Upon the remaining shares the full amounts have been called, and all calls (£21,510) have been paid.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 7th were £919, as against £822 for the corresponding period of last year, being an increase of £97. The total receipts for half-year amount to £4,703, against £4,299 in the corresponding period of 1891, being an increase of £404.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—Notice is given that the transfer books and register of members of the above Company will be closed from Thursday, the 18th inst., to Wednesday, the 31st inst., both days inclusive.

COMPAGNIE DE L'INDUSTRIE ELECTRIQUE GENEVOISE.—The accounts submitted to the recent general meeting of this Company showed a net profit for fifteen months' working of the Geneva Central Station, sale of apparatus, and the construction branch, of 130,709 francs, and a dividend of 5½ per cent. was declared. In order to consolidate its floating debt, and to provide for construction of new works, the Company have decided to issue Four and a-Half per Cent. Obligations to the amount of 800,000 francs.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for July, 1892, amounted to £23,200; and from January 1st to July 31st to £152,000. In the corresponding months of 1891 and 1890 the amounts were £165,800 and £156,000 respectively.

MUNTZ'S METAL COMPANY (LIMITED).—The Directors notify an interim dividend for the half-year ended June 30th at the rate of 10 per cent. per annum, payable on the 1st prox.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—An interim dividend for the half-year ended 30th June last, at the rate of £3 per cent. per annum, has been declared. This dividend will be payable on the 15th September.

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ONCKEN PATENT STAVELESS BARREL COMPANY (LIMITED).—The prospectus of this venture has been issued, and contains the statement that Mr P. Allen, late chief engineer to the Anglo-American Brush Electric Light Corporation (who is the engineer to the Company), and Messrs. Bonhoulle and Paun, engineers of Antwerp, have reported favourably on the advantages and efficiency of the electrical process owned by the Company for seasoning wood.

PIONEER TELEPHONE COMPANY (LIMITED).—Notice is given that an extraordinary general meeting of this Company will be held at Winchester House, E.C., on Tuesday, the 16th inst., at 2:30 p m., for the purpose of considering, and, if thought fit, passing the following resolution :—"That the Company be wound up voluntarily." Should the above resolution be passed by the required majority it will be submitted to a subsequent extraordinary general meeting for confirmation as a special resolution. The meeting will also be asked to pass a resolution fixing the amount to be paid to the Directors by way of remuneration for their services.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 5, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,771.

WOODHOUSE AND RAWSON UNITED (LIMITED).—The Stock Exchange Committee appointed yesterday (Thursday) a settling day in the further issue of this Company's ordinary shares, Nos. 90,001 to 105,200, and preference shares No. 70,001 to 81,088.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. Aug. 3.		Price Wednesday, Aug. 10.		Rate per Cent. Yielded.	Dividend Due.	Business done during week ending Aug. 10.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS								
£1,247,720	Stock	12/6	Anglo-American	47½	48½	47	48	5 10 0	Jan., Apr., July, Oct.	47⅞	47
£2,476,140	Stock	25/0	Do. Preferred	87½	88½	87½	88½	6 10 0	" "	88½	87½
£2,476,140	Stock	5/0	Do. Deferred	11	11⅛	10½	11½	..	" "	..	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	103	100	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	10¼	10⅜	10¼	10½	6 10 3	Mar., June, Oct., Dec.	10⅛	10⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	99	102	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	160	165	160	165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11	12	11	12	6 13 4	February and August	11½	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	17½	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3¾	3½	3¾	4 16 9	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½	11¾	11½	11¾	5 19 2	Jan., Apr., July, Oct	11⅞	11½
400,000	10	5/6	Eastern	14⅜	15	11⅝	14½	4 7 5	" "	14½	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15½	15⅞	15½	15⅞	3 16 2	" "	15⅞	15½
£1,200,00	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108	111	109	112	3 11 5	May and November	111	1 09½
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106	109	106	109	4 11 9	February & August	107	
250,000	10	2/6	Eastern Extension	15	15½	15	15½	4 12 7	Jan., Apr., July, Oct.	15⅝	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	108	111	3 12 9	February & August	110	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	103	106	4 14 4	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	101	104	102	105	4 15 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	103½	101½
180,227	10	3/0	Globe Telegraph and Trust	10	10½	10	10½	4 15 1	Jan., Apr., July, Oct.	10⅝	10
180,042	10	6%	Do. 6 per Cent. Preference	15	15⅛	15⅜	15⅝	3 18 1	" "	15⅞	15
150,000	10	5/0	Great Northern	18½	19	18½	19	4 9 6	Jan., April, and July	18⅞	1-⅝
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	103	109	107	110	4 10 11	March & September	..	..
17,000	25	1½	Indo-European	41	43	41	43	5 16 3	May and November	42	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	108	111	5 8 1	March & September	..	..
10,802	8	8/0	Reuter's	7	8	7	8	5 0 0	April and October	7⅞	..
3,381	£100 Cert.	£1½	Submarine Cables Trust 6%...37/6 Bal. Ap. Coup.	115	120	115	120	5 0 0	" "	116	..
15,609	10	5/0	West African Telegraph	6	8	6½	7½	5 6 8	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	101	104	4 16 2	March & September	102½	..
30,000	10	2/0	West Coast of America	3	4	3	4	..	January and July	3⅛	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	104½	103
£8,321	10	6d.	West India and Panama	1⅛	1⅜	1	1¼	..	" "	1¼	
34,563	10	6%	Do. 6 per Cent. 1st Preference	9¼	9⅝	9¼	9⅝	6 3 1	May and November	9½	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8	9	8	9	6 13 4	" "	8⅞	8½
£4,212	15	6/0	Western and Brazilian	8⅞	9⅛	8⅞	9⅛	6 9 7	" "	9	8⅛
33,129	7½	1/3	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 7	" "	6⅛	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾	3⅛	2¾	3⅛	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102	105	102	105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102	105	102	105	5 14 3	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
£24,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛	⅜	⅛	⅜	6 10 10	May and November	..	..
£20,000	£1	4½d.	Oriental (11s. paid)	⅛	¼	⅛	¼	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅛	4⅜	4⅛	4⅜	6 6 4	June and December	4⅞	4¼
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½	14	13½	14	4 5 9	" "	14	13⅞
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13	13½	13	13½	4 8 11	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109	111	109	111	4 1 1	January and July	110½	109½
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	9⅞	10⅛	9⅞	10⅛	..	—	10	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	..	..	2⅛	3⅛	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	..	5	5⅛	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5⅛	5⅜	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16	3 9/16	3 7/16	3 9/16	..	March	..	..
10,000	£5	4%	Do. (fully paid)	5 1/16	5 3/16	5 1/16	5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	¾	1⅛	¾	1	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾	7⅛	6¾	7⅛	..	—	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4	5	4	5	—	—	..	..
18,680	£5	2/6	St. James' and Pall Mall	7⅛	7⅜	7⅛	7⅜	—	..	7⅛	..
7,900	£5	7%	Do. 7% Preference	7⅞	8⅛	7⅞	8⅛	—	..	..	..
42,853	5	..	Westminster Electric Supply (fully paid)	5¾	6¼	5¾	6¼	..	..	5	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	2⅞	3⅛	2⅞	3⅛	..	..	3 1/16	3
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2⅛	..
20,000	5	8/6	Crompton and Co., 7 per Cent. Pref. Shares	5⅝	6	5⅝	6	5 16 8	January and July	5⅝	..
12,139	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	4⅞	5⅛	4⅞	5⅛	..	—	5⅛	4⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅝	2⅜	2⅝	—	—	2 1/16	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	20½	21½	21	22	5 16 3	February & August	21⅛	21⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104	106	104	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½	4½	3½	4½	..	..	..	..
11,334	£10	8/0	Do. Preference	6	7	6	7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1/16	¼	¼	⅜	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3	3⅛	3	3⅛	11 0 0	May and November	3⅛	3⅛
37,350	12	12/0	Telegraph Construction and Maintenance	44	46	44	46	5 4 6	March and July	45½	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103	106	103	106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	..	⅛	⅜	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	..	..	2½	3	..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	..	..	..	..
50,000	£10	..	City and South London Railway	2½	3¼	2½	3½	—	..	..	..

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THE ELECTRICIAN:

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NOTES.

In our issue of the 22nd July we published a letter which had been issued by the Secretary of the London Chamber of Commerce to the members of the Electrical Trade Section, inviting them to fall in with the suggestion of Mr. Preece with regard to the Chicago Exhibition, that a suite of rooms should be appropriately fitted up and lighted by electricity, so as to give some idea of the state of electrical engineering in this country. We now learn that not a single favourable response has been received to that circular. The electrical trade evidently agrees, as we anticipated it would, with the makers of steam engines, that there is nothing to be gained by exhibiting.

The outcome of the discussion on Electrical Standards at the British Association was the recognition by the representatives of Germany and France of the accuracy of the determinations which had been adopted by English electricians, who, in return, gave way upon the definition of the unit.

A delicate distinction has been drawn between a standard and a unit. As far as we understand it, the unit defines the standard, and the ohm as a unit is, in deference to continental wishes, to be a mercury column. This column is to be 106·3 centimetres long and of one square millimetre section. Most of our readers who have given this matter any attention are aware that in 1884 the length 106 was adopted at the Paris Conference, although there was strong evidence to show that 106·25 was nearer the true value. It was a fight, as Lord Kelvin said at the Leeds meeting, of 106 or nothing. Measurements have since been carried to a much greater degree of accuracy, and our continental friends have been obliged to admit the ·3.

The Weights and Measures Act is a marvellous affair, but we understand that the B.A. committee have succeeded in matching it by so wording their resolution that no one need trouble after all to measure his 106·3 centimetres, or, what is much more difficult, if indeed it is possible, to measure the internal sectional area of his tube; for he will be provided with a standard, and this will be a metal wire, or rather a number of coils between which comparisons will be made, as Mr. Glazebrook has continually done with the B.A. and other coils under his charge. The report of the committee should be considered with the discussion which followed, and with the arguments which led to it; and we therefore postpone its publication until next week, when we hope to give it in full, together with these necessary additions.

The delay in the issue of certificates for approved patterns of electric supply meters by the Board of Trade has not been due to want of completion of the Laboratory of the Electrical Standards Department, or to any shortcomings of the staff, but is clearly explained by the letter from Sir Courtenay Boyle which will be found in another column. The Shallenberger meter alone has received approval for certain Provisional Orders, and of course for alternating currents only; but this approval, it is explicitly stated, will not at present be further extended. With this exception, no meter whatever has yet been certified by the Board of Trade; and although two meters of the motor type passed the laboratory tests with a sufficient degree of success to satisfy the required conditions, reports of the behaviour of these instruments in regular work have, we believe, made it necessary to postpone the issue of certificates for the present, and it is evident that the "thorough practical test" which is referred to is something more than the careful scientific examinations which have hitherto been made.

It would doubtless have been possible to have issued provisional certificates, and at first sight this would appear to be a convenience both for the consumer and for the supply company, but such a course would really benefit only the meter-makers, for it would encourage the supply of meters which might afterwards have to be abandoned. As the certificates of the Board of Trade approve of a type of meter, and not individual instruments, the whole of these meters would have to be remodelled if, indeed, they were not placed, patents and all, *hors de combat*.

The examination of electric supply meters has been most carefully conducted, not so much to test the degree of accuracy of the specimens which were submitted to the Board of Trade, but to prove the proportionality of their readings to the current or energy sent through them, both under ordinary conditions, and at different temperatures and atmospheric pressures. It is rather fortunate that these examinations were carried on with some deliberation, since far less scientific but very important tests were being conducted elsewhere on a

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large scale—that is to say, many hundreds were in daily use; and the behaviour of these, rather than of the meters sent in for approval, have led to the postponement of any formal decisions.

THE promise which a diminishing deficit in the telegraph revenue two years ago seemed to hold out has been rudely broken in the year just past. According to the Postmaster-General's annual report, the balance on the wrong side is again nearly what it was in the years preceding 1888, and double the amount at the end of 1890. This is the more disappointing seeing that the number of telegrams goes on increasing at much the same rate as heretofore. The explanation seems to be that the expenditure increases at a much higher rate, and the revenue at a rather lower rate. Increased wages paid to operators partly, no doubt, account for the former, and decreased payment for messages explains the latter. The average value of the "sixpenny" telegram continues to dwindle as customers learn to economise words, or adopt a registered address. Then, again, the Continental tariffs have been greatly reduced, and the profits from that quarter still further lessened by the cable telephone wires, traffic over which, although paid for at high prices, disproportionately reduces the number of ordinary telegrams.

FROM a commercial point of view, however, the whole report, so far as it relates to the telegraphs, is highly satisfactory. The briefer and the cheaper messages become, the greater number can be despatched by the public and disposed of with increased efficiency and speed by the department. The cheapening of telephone and private wire rentals is equally gratifying to the business community, though we do not gather that the revenue will greatly profit by it. An extension of this class of work to the telephone trunk lines will result probably in further augmentation of the telegraph deficit. Here we cannot help repeating our expression of surprise that the separation of telegraph from Post Office accounts continues to be maintained. By itself the telegraph department would never have taken up with the several unremunerative reforms into which from time to time it has been driven; and the Post Office, which does all the driving and gets most of the praise, ought to bear the burden of the loss. But as long as the accounts are kept separate so long will the afflicted telegraphs be credited—or rather discredited—with being a poorly paying adjunct of the Post Office, whereas if left to itself the telegraphs would be a highly profitable concern.

IT is somewhat sobering to note into what a small compass the life's work of even the most active amongst us can be compressed when the narrative is confined to a mere catalogue of things done, the proper appreciation of them being left to the unaided intelligence of those who may chance to be interested in the story. But "an honest tale speeds best being plainly told;" and the services rendered to the cause of electrical science by SAMUEL VARLEY are not likely to escape recognition merely because the Varley Testimonial Committee have, in the circular letter which we reprint in another column, wisely avoided all debatable dicta and limited themselves to a bald statement of fact. The rank and file of the electrical profession are not for the most part overburdened with riches; but if everyone who reads the appeal of the committee contributes out of his "lean and low ability," the recognition of Mr. VARLEY's work will be as widespread as we trust it will be substantial.

AT the meeting which was held at the Westminster Palace Hotel in July last, Mr. CROMPTON confessed to having known next to nothing of Mr. VARLEY and his discoveries until, at the end of 1888, Messrs. KING, BROWN AND CO. chivalrously elected to contest the validity of BRUSH's so-called compound-winding patent, No. 2,003 of 1878. Were the rest of the electrical profession as refreshingly candid as Mr. CROMPTON, we are afraid they would have to plead guilty to a similar state of ignorance. Indeed, the faculty which some men possess of being lost sight of is quite as astonishing as the happy knack which others have of being always in evidence.

YOUR true inventor, that is to say, one who is afflicted with a mania which keeps him for ever at the treadmill devising curiosities of ingenuity quite regardless of the existence or non-existence of any demand for them, is notoriously a sanguine man. But hope, as someone has aptly put it, is not the man for your banker, though he may do for your travelling companion. Hence the oft-told tale of failure followed by neglect, resulting but too frequently in sour suspicions of the integrity of mankind in general, and of successful contemporaries in particular.

To make invention a paying pursuit a good solid dose of business-like shrewdness is absolutely indispensable. It is necessary to seize the psychological moment for putting your patented wares upon the market; on no account must you be before your time; and there must be no illusions as to the tangibility of that asset known as fame. Pursued in this fashion, invention degenerates into mere patent-mongering, but it leads to wealth. Nevertheless, to the credit of humanity be it said, when attention has once been directed to the overlooked services of pioneering patentees, the question of whether any debt is due to them is not, as a rule, examined in any quiddling spirit, unless, indeed, like Mr. LANE FOX, they put themselves out of court by going to law.

Maidstone.—The Maidstone authorities contemplate erecting an electric lighting station, at a cost of about £12,000.

Partick.—The Police Commissioners of Partick, one of the suburban burghs of Glasgow, are about to apply to the Board of Trade for an Electric Lighting Provisional Order.

Electric Railways in London.—The Corporation of the City of London have issued a Blue Book dealing with the Electric Railway Bills introduced into the late Parliament.

Honours.—Amongst the list of honours which appeared in yesterday's papers as approved of by the Queen is the following:—Sir John Pender, K.C.M.G., M P., to be G.C.M.G.

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Cardiff.—At the last meeting of the Town Council a lengthy report, which had previously been presented to the Lighting and Electric Committee by the Sub-Committee and accepted, was submitted to the Council and adopted. The report estimated the approximate cost of electrically lighting the borough at between £25,000 and £30,000.

Underground Mains in Paris.—With a view, it is said, of diminishing the chances of further explosions on their system of underground mains, the Compagnie Continentale Edison are giving their bare copper conductors a coat of tar. On the other hand, the municipal electric light engineers are trying the effect of ventilating the conduits, a fan driven by a couple of men being used at different points on the network.

Chatham.—At the last meeting of the Town Council the following motion was adopted:—"That the Corporation shall take such steps as may be necessary to acquire and purchase the interest in the Chatham Electric Lighting Company, if the said Company are disposed to sell at a price advantageous to the ratepayers—the matter to be referred to the same Committee appointed to consider the question of the Waterworks, and report."

Electric Launches on the Seine.—Last week the Paris agent of Woodhouse and Rawson United gave the representatives of the electro-technical Press a run on board the electric launch, "L'Éclair." The launch is 11 metres long and 1·8 metre beam, and draws 40cm. of water; its maximum speed is about 12 kilometres an hour, and it can run six hours at full speed. Current is obtained from a 40-cell battery of Epstein accumulators, having a capacity of 160 ampere-hours, on a discharge of from 25 to 30 amperes.

Junior Engineering Society.—This society has provided an excellent series of summer excursions for its members, extending from the 12th to the 20th of August. It has been contrived that the maximum number of places should be visited in this short space of time, including the large engineering works at Crewe, Chester, Manchester, Bolton, the Ship Canal, and Liverpool. From the programme which has been issued to members of the society the details of the excursion seem to have been arranged with a considerable amount of forethought.

Accumulator Patent Litigation in France.—Judgment in the action brought by the Compagnie Française des Accumulateurs Faure-Sellon-Volckmar (Philippart et Cie.) against MM. Rousseau and Paul Gadot has, says our Paris correspondent, just been given. M. Constant Rousseau has been held not to have infringed the patents owned by the Compagnie Française, but M. Paul Gadot has been fined 500fr. and condemned to pay 5,000fr. damages as well as the costs of the action. It is said that an appeal will be lodged against this decision, the damages awarded being deemed insufficient.

Telegraphic Rates to Australasia.—According to a Reuter's telegram the Conference of Australasian Postmasters-General, recently held at Melbourne, has decided to recommend to the various telegraphic administrations interested in telegraphy to the Far East an increase of 9d. per word in the charge from October 1st next. It is also announced that the proposal of New Zealand to join the other colonies in guaranteeing the Companies a certain proportion of any loss from the low rates has been accepted, and the tariff between New Zealand and London will consequently be reduced to 5s. 3d. per word.

Thunderstorms in Spain.—The destruction of life and property caused in Spain by storms has this year been of an unprecedented character, says a Reuter's telegram from Madrid. Not a month has passed since last May without a number of thunder and hail storms, which destroyed the crops in many districts, while the loss of life and damage through lightning has been exceptionally heavy. Telegrams received to-day (August 11th) from Saragossa bring details of the desolation wrought by storms in the districts of Borja and Ateca. At Osera a woman was killed by lightning, and at Lechando two boys met with their death in the same way, while two others were injured by the electric current.

Prescot.—The Local Board have accepted the offer of the British Insulated Wire Company, whose works are at Prescot, to light the town and district with 12 arc lamps and 70 incandescent lamps at a cost of £350 per annum for five years. The estimate of the firm included everything connected with the lighting of the town. The total cost of gas for the year ended March 31st last was £312. The Gas Company, however, had offered to make a reduction of 2d. per 1,000ft., which would amount to about £8 on the consumption of last year. Mr. Yeaman, representing the firm, explained that the whole of the new arrangements could be completed and the district supplied with the light in the course of about one month.

The Electric Lighting of the City.—The City of London Company expect to have over 500 street arcs alight by the end of October.—A meeting of the St. Bene't Fink Vestry was called last week to consider the advisability of utilising a portion of the site of the old churchyard of St. Bene't Fink for the parish benefit. The Vestry approved of an application being made by the rector and churchwardens, in conjunction with the Corporation, for a faculty to permit the City of London Electric Lighting Company to construct in the churchyard a transformation chamber or vault, and to place in it certain apparatus for the conversion of electricity. The Vestry also approved of a draft agreement by which an annual contribution will be paid by the City of London Electric Lighting Company to the parish for the general expenses of Divine service in the church.

Bristol.—On Friday Mr. Rienzi Walton, one of the inspectors under the Local Government Board, held an inquiry at Bristol relative to the application of the Town Council for permission to borrow £66,000 for the purpose of electric lighting. The Town Clerk, in reply to the inspector, said that the population of the city at the last census was 221,700. The assessment value was £1,042,974. The indebtedness of the Corporation other than as the Sanitary Authority was £268,704, and as the Sanitary Authority it was £385,918; but there was also a considerable indebtedness in connection with the Dock Estate. The Town Clerk explained that until a year or two ago they were advised by eminent authorities on electric lighting that they did wisely in holding their hands for a further development of the science. They now proposed to have an installation, and the money was required for the erection of a central station and for laying down the necessary plant. There was no objection to the application.

Hastings.—Some three years ago (Sept., 1889) the Hastings Town Council were led to believe that they would be doing a good thing for themselves by undertaking the electric lighting of the sea front, as they would have "with the dust destructor boiler" sufficient power for the purpose, and would save £180 per annum upon the £450 then being paid. We now learn from the local papers that the Corporation are not disposed to take upon themselves the work of lighting the public streets, and that at the last meeting of the Council a report was presented recommending that arrangements be made with the Electric Light Company for lighting the whole three miles of the sea front, though for the present the proposal remains in abeyance. At present only three-quarters of a mile of the most frequented portion of the esplanade is electrically lighted, 16 lamps, at intervals of 100 yards, being erected. If the new proposal is carried into effect there will be 51 arc lamps, 80 yards apart, and the cost at £25 per lamp will be £1,275. After midnight each alternate light is to be extinguished.

Southport.—The scheme and plans for the electric lighting of Southport, prepared by Mr. Geo. Wilkinson, involving the expenditure of £28,000, exclusive of land, were unanimously adopted by a special Town Council meeting, held on Monday night last. The system adopted is that of high-pressure alternating currents, and the generating station is to be erected on a site adjoining the present gas works, 1½ miles out of town. Special provision is being made in the generating station for burning refuse fuel from the gasworks, and water is available for condensing. With these economies and the advantage to be derived from working the gas and electric lighting businesses together, the actual cost of producing the electrical energy is expected to be very low. Trunk mains (in duplicate) will be laid to transformer substations in the town

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and residential districts of Hesketh Park, where low-pressure distributing mains will be laid. The full equipment of the station will be as follows:—Three sets (horizontal engines and dynamos), each equal to an output of 100 units, two 50-unit sets, and one 25-unit set, the alternators working in paralled. It is proposed to supply electric current to consumers by meter, at 6d. per unit, until the profits of the business justify a reduction.

Launceston (Tasmania).—The Launceston Town Council lately adopted a report in favour of electrically lighting the city, the scheme adopted being one prepared by Mr. K. L. Murray, of Melbourne. Mr. Murray's plan, the execution of which will cost some £45,000, involves the use of the water of the South Esk River to supply the necessary power. It is proposed to run a 42in. pipe from a generating station to be situated at the first basin, which is about 1¼ miles from the south-west boundary of the city, to a point 55 chains up the river, where will be the race and intake. The total head from this point to the first basin is 110ft.; but, the station being 35ft. above the ordinary level of the basin, allowing an effective suction of 15ft., 90ft. will be the available head. Making liberal allowance for all losses, 470 H.P. is by this means obtainable at the turbine shafts, whilst any possible future increased demand for light will be met by a further installation of a 40in. pipe laid upon the top of the first, giving an additional 390 H.P. The dynamos will be coupled direct to the turbines, five of 20 H.P. each being used for arc lighting, and six of 90 H.P. each for incandescent lighting. The current will be conveyed into the town by overhead mains, suspended from steel bearer wires. It is proposed to light the business part of the town with 125 arc lamps, fixed in the middle of the streets on wooden poles 30ft. high. The incandescent lighting dynamos will supply current at 2,000 volts, to be transformed down to 100. One machine is to be used for lighting the streets in the residential districts with 200 50-c.p. lamps.

The Postal Telegraph Service during 1891-92.—The following extracts from the thirty-eighth annual report of the Postmaster-General relate to the telegraph service:—The telegraph money order business, although restricted until the last month of the financial year to head and branch post-offices only, showed a considerable expansion, there having been 42,055 such orders issued in 1891-92, as against 30,196 in 1890-91, while the amount remitted was £157,428, as compared with £112,570. The following table shows the number of telegrams and the receipts thereon for the year ended March 31st last, and also for the preceding year:—

Class of Telegrams	Year.	Number.	Increase.	Receipts.	Increase.
Ordinary Inland ...	1891-92	57,085,939	2,969,526	£1,848,974	£74,352
„ „	1890-91	54,116,413	—	1,774,622	—
Press (Inland).....	1891-92	5,180,278	176,869	116,247	3,098
„ „	1890-91	5,003,409	—	113,149	—
Foreign	1891-92	5,553,659	73,131	261,251†	470
„	1890-91	5,480,528	—	260,781	—
Railway	1891-92	1,606,665	71,598	Nil.	—
„	1890-91	1,535,067	—		
Government	1891-92	258,939	14,855*		
„	1890-91	273,794	—		
Totals	1891-92	69,685,480	3,276,269	2,226,472	77,920
„	1890-91	66,409,211	4,005,812	2,148,552	106,799

* Decrease. † Of this sum £4,616 was received in fees for conversations on the Paris telephone.

It will be seen that the increase in the number of messages of all kinds over that of the previous year is 3,276,269, or 4·9 per cent. The average value of an inland telegram is now 7·77d., as compared with 7·87d. for last year. The results of the working of the London-Paris telephone have been satisfactory. The number of conversations has increased from 1,221 during the month of April, 1891, to 2,157 in April, 1892.

Telegraphic Communication with Lighthouses.—The following is the latest programme of the Royal Commission appointed to inquire into electrical communication between lightships and lighthouses and the shore in England, Ireland, and Scotland:—Monday, August 15th, the Commission assembled at the North-Western Hotel, Liverpool, where they met the Mersey Docks and Harbour Board, with whom they visited the Mersey light vessels. Tuesday, August 16th: Visit to Liverpool lighthouses thence to Holyhead, thence to Kingstown. Wednesday, the 17th: Conference with the Irish Lights Commissioners, and visit to the Kish Lightvessel and the Howth Bailey Lighthouse. Thursday, the 18th: Commission left Kingstown to visit light stations on the east coast of Ireland, thence to Milford Haven. To-day (Friday), the 19th: The Commission goes on board H.M. despatch vessel Enchantress, at Milford, and visits Caldy, Helwick, Scarweather, Nash, Flatholm, and Cardiff. Saturday, the 20th: Visit to the Scilly Isles. Monday, the 22nd: Visit to Bishop Rock, Round Island, and Seven Stones light vessels, Longships, the Lizard, and Eddystone. Tuesday, the 23rd: Examination of Swanage Bay, Anoil Point, the Needles, and Portsmouth. Wednesday, the 24th: Visit to Dover, Goodwin Group, and Ramsgate. Thursday, the 25th: Visit Thames entrance and group of lighthouses and lightships, as far as Stairborough. On Wednesday, the 31st, the Commission goes to Edinburgh, and on the following day will confer with the Northern Lighthouses Commissioners, visiting May Island and North Carr the following day.

The Birmingham Accumulator Cars.—The working of the accumulator cars on the Bristol Road line of the Birmingham Central Tramways Company's system during 1891-92 has resulted, according to the Directors' report, in a loss of £1,679. The total receipts were £10,422; 188,760 miles have been run, and 1,382,997 passengers have been carried by the electric cars. The report, which will be found in another column, states that the loss is chiefly due to the heavy charges for renewal of batteries, and that the Directors have under consideration a contract for the maintenance of the batteries, which, it is hoped, will tend to material economy. The following detailed figures will be of interest:—

Average per mile run. d	d.		£ s. d.	£ s. d.
		To Electric Haulage:—		
3·38		Wages	2,657 9 11	
1·65		Fuel	1,300 8 0	
·66		Stores	517 2 8	
·10		Water and lighting.....	78 7 6	
·09		Sundries	71 13 7	
	5·88			4,625 1 8
		„ Machinery:—		
0·81		Wages	638 9 10	
3·22		Materials	2,529 7 11	
	4·03			3,167 17 9
		„ Car Repairs:—		
0·36		Wages	280 8 9	
0·75		Materials	593 9 5	
	1·11			873 18 2
		„ Traffic Expenses:—		
1·24		Wages	977 12 1	
0·09		Water and lighting	68 11 9	
0·01		Stores	9 5 3	
0·08		Stationery, tickets, and punch royalty	61 4 10	
0·02		Sundries	15 9 10	
	1·44			1,132 3 9
		„ Permanent Way and Buildings:—		
0·02		Wages	12 6 9	
1·70		Materials	1,339 18 0	
	1·72			1,352 4 9
		„ General Charges:—		
0·11		Stationery and incidentals...	86 7 2	
0·11		Salaries.....	85 5 5	
0·11		Compensation	87 3 0	
0·55		Rates, taxes, and insurances.	433 3 6	
0·30		Professional charges	233 6 10	
0·03		Sundries	25 3 8	
	1·21			950 9 7
	15·39			£12,101 15 8

The totals for the other departments are as follows:—

Department.	Miles run.	Passengers carried.	Total receipts.	Total cost per car mile run.
Steam	1,212,624	14,659,240	£80,625	12·03d.
Horse (trams and 'buses)	634,551	3,753,741	29,606	9·95
Cable	621,210	5,922,304	31,585	6·18

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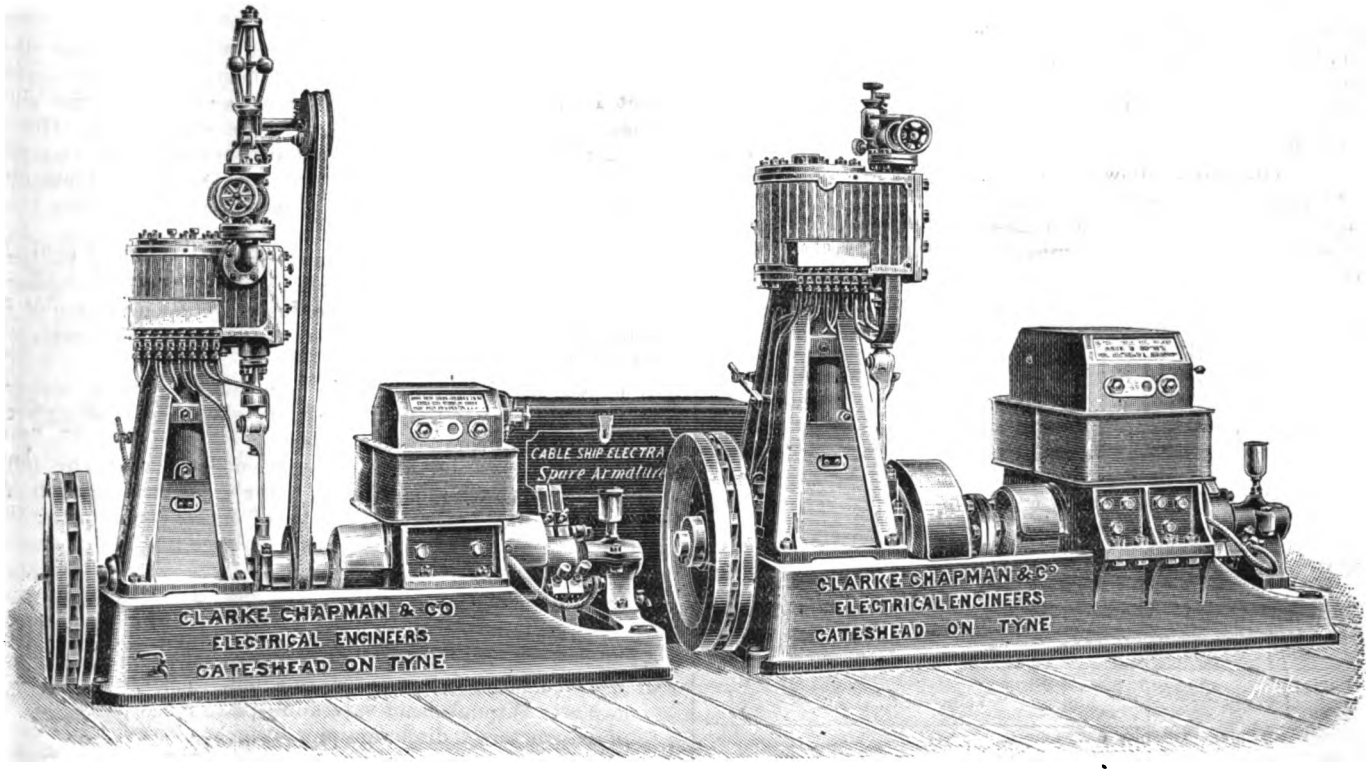
THE ELECTRIC LIGHTING PLANT OF THE CABLE SHIP "ELECTRA."

The cable ship "Electra," belonging to the Eastern Telegraph Company, has recently been fitted with a new electric lighting plant. The old machinery consisted of four old-fashioned Gramme dynamos, each giving 35 amperes at 100 volts at 1,200 revolutions, and driven through belting by two Willans three-crank engines of a very early form, running at 400 revolutions. Two sets, shown in the accompanying illustration, have now been provided, one giving 185 amperes, and the other 75 amperes, both at 65 volts. The dynamos and direct-coupled engines have been built by Messrs. Clarke, Chapman, and Co., of Gateshead. The engines are of a very substantial and compact design, and are of the inverted vertical single-cylinder open type. The standards consist of a double A frame, in one casting. The crossheads have large cylindrical bearing surfaces. The 185-ampere set runs at 250 revolutions, the floor space occupied being 7ft. by 3ft., and the engine is provided with a flywheel governor acting on the eccentric. The smaller set runs at 310 revolutions, the floor space occupied being 5ft. 10in. by 2ft. 6in., and the engine being shorter there is head room for a Pickering governor acting direct on the valve spindle. The steam pressure employed is 80lb. when supplied by the main boilers, and 60lb. when supplied by the donkey boilers. The armatures are both drum-wound, and the fields are compound-wound. A switch-board with nine circuits distributes the current. It includes an arrangement whereby the well-known method of detecting a leak in a lead by putting the opposite lead to earth through a voltmeter can be easily carried out. A projector with an 18in. mirror is mounted on the flying bridge, and is provided with diverging lenses. It is hoped that the beam will enable buoys to be sighted at a distance of two miles. Groups of glow lamps, consisting of six 16 candle lamps, are preferred to arc lamps for night work on deck. A group of five lamps is fitted immediately under the bow for giving light for work over the bow.



The Electric Lighting Plant of the Cable Ship "Electra."

CONDENSERS AND PUMPS.*

Condensers are of two types, viz., Jet Condensers, in which the steam and condensing water mix in a common vessel, from which both are pumped by the air-pump; and Surface Condensers, in which the steam generally passes into a chamber containing a number of brass tubes, through which the condensing water is made to circulate. The latter form is generally adopted where water is bad, as it enables the same feed-water to be passed through the boiler over and over again, and, under favourable circumstances, a vacuum of 28in. can be obtained, while 25in. to 26in. is as much as can be expected with jet condensers.

The capacity of a jet condenser should not be less than one-fourth of the low-pressure cylinder, but need not exceed one-half unless the engines are very quick running; one-third is a good average ratio. Large condensers require more time for forming the vacuum, while small condensers are liable to flood and overflow back to the cylinders. The amount of condensing water required per lb. of steam condensed varies with the temperatures of the exhaust, of the "hot-well," and of the condensing water. (The "hot-well" is the receptacle into which the air-pump delivers the water from the condenser.) The feed-water is obtained from the "hot-well," which should be maintained at 110° to 120° F. Sometimes even 130° F. can be got with care.

Surface condensers occupy more space than jet condensers, and require a second pump for circulating the condensing water generally, though the air pump may be smaller than that required for an equivalent jet condenser. The amount of cooling or tube surface depends upon the difference between the temperature of the exhaust steam and the average temperature of the cooling water, and on the thermal conductivity and thickness of the metal tubes. For copper and brass tubes in good condition the rate of transmission is about 1,000 units (equivalent to about 1lb. of steam condensed) per square foot

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per 1°F. difference of temperature per hour. With the hot-well at 110° and the cooling water at 60°, the average difference is 25°, and 25lbs. of steam should be condensed per hour per square foot. In practice allowance must be made for the working conditions of the tubes, and half the above, *i.e.*, $\frac{1}{2}$lb. of steam per 1°F. difference is nearer the usual allowance; and under the above conditions about 12·5lbs. of steam would be condensed per square foot per hour, which is considered very fair work. In marine engines an allowance of 1·5 to 3 sq. ft. per I.H.P. is made according as the terminal pressure of exhaust varies from 6lbs. to 30lbs. (absolute); for the tropics 20 per cent. more, and for cold climates 10 per cent. less suffices.

The tubes are generally of brass, No. 18 S.W.G. thick, and from $\frac{1}{2}$ to 1in. diameter, according to the length of the tubes; they are mostly $\frac{3}{4}$in. in diameter, and spaced at a pitch of $1\frac{1}{4}$in., while the tube-plates, which are also of brass, are $1\frac{1}{8}$ to $1\frac{1}{4}$in. thick for $\frac{3}{4}$in. tubes. The length of the tubes, when unsupported between plates, should not exceed 120 diameters.

If H = total heat of 1lb. of exhaust steam in British Thermal Units (B.T.U.),
t = temperature F.° of hot-well,
t_1 = temperature F.° of cooling water on entering,
t_2 = temperature F°. of cooling water on leaving,
Q_1 = quantity in lbs. of cooling water per lb. of steam for jet condenser,
Q_2 = ditto for surface condenser;

$$Q = \frac{H - t}{t - t_1},$$

$$t = \frac{H + Q_1 t_1}{1 + Q_1} \text{ for jet condenser,}$$

$$Q_2 = \frac{H - t}{t_2 - t_1},$$

$$t = H - Q_2 (t_2 - t_1) \text{ for surface condensers.}$$

N.B.—H - t = 1,050 approximately.

Values of Q_1 and Q_2 for different temperatures of cooling water when H = 1,150 t = 110, and t_2 = 100 in case of Q_2:—

	Values of t_1.				
	40	50	60	70	80
Q_1	15	17	21	26	35
Q_2	17	21	26	35	52

Area of injection orifice should be such as to allow a velocity of flow of water not exceeding 1,500ft. per minute. It is better to have a large orifice and to control the flow of water by an injection valve.

Area of orifice in square inches = lb. water per minute ÷ 650 to 750.

= area of piston ÷ 250.

The cooling or circulating water in surface condensers should travel some 20ft. lineally through the tubes. In small condensers, where this is not convenient and the water only circulates twice through short tubes, the rate of flow must be reduced.

A replenishing cock should be fitted to allow of the passage of part of the circulating water into the air-pump suction to provide for water lost in drains, blowing off, leakage, &c. This may have $\frac{1}{10}$ the area of the feed pipe. A cock should be fitted close to the exhaust inlet for introducing caustic soda when required to dissolve grease off the tubes.

Air Pumps.

Air-pumps are used to draw the condensed water from the condenser to the hot-well, together with the air originally contained in the water, or which may find its way in through glands, &c., and with jet condensers they also draw the cooling water. A cubic foot of ordinary water contains about 0·05 cubic foot of air at atmospheric pressure, which expands in the condenser to about 0·4 cubic foot of air, hence the term air-pump.

The efficiency of a single acting air-pump may be taken at 0·6 to 0·4 and generally 0·5, while that of the double acting pump may be 0·5 to 0·3, say 0·4 on average. For jet condensing the volume of the air-pump should be theoretically 1·4 times the volume of condensed + cooling water; for good working it should be from twice to thrice that required by theory. Or if

v = volume of condensed water per minute in cubic feet.
V = volume of cooling water per minute in cubic feet.
n = number of strokes (useful) of air-pump per minute.
A = volume of air-pump;

$$A = 2{\cdot}8\frac{v + V}{n} \text{ for single acting pumps.}$$

$$= 3{\cdot}5\frac{v + V}{n} \text{ for double acting pumps.}$$

Since, for surface condensing, the air-pump does not draw the cooling water, and as the feed-water being used over again should not contain so much air, it would appear that the air-pump might be much smaller than for jet condensing. However, surface condensers are frequently arranged for use as jet condensers in case of mishap, and with surface condensing a better vacuum is expected, so that for surface condensing the air-pump is only slightly less than for jet condensing. In actual practice the air-pump is made from $\frac{1}{10}$th to $\frac{1}{25}$th the capacity of the low-pressure cylinder, according to the number of expansions and nature of condensers while a comparison of a number of marine engines by different makers shows a ratio of $\frac{1}{16}$th to $\frac{1}{21}$st.

If expansion joints are used in the exhaust pipe a copper bellows joint is better than the ordinary gland and stuffing-box type, through which air is apt to leak.

Air-pump valves should have sufficient area that the full quantity of cooling and condensed water in jet condensation in passing does not exceed a velocity of 400ft. per minute; in practice the area is larger than this. A large number of small valves is perhaps better than one or two large valves which are sluggish owing to their inertia. The clearance space between head and foot valves should not exceed $\frac{1}{15}$th the capacity of the pump as ordinarily constructed.

If a = area through foot valves in square inches,
a_1 = area through head valves in square inches,
d = diameter of discharge pipe in inches,
D = diameter of the air-pump in inches,
S = speed (useful) in feet per minute;

$$a = \frac{1}{1{,}000} D^2 S,$$

$$a_1 = \frac{1}{800} D^2 S,$$

$$d = \tfrac{1}{3}\tfrac{1}{3} D \sqrt{S}.$$

If there be no air vessel or receiver, d should be 10 per cent. larger. An air pipe should be fitted to the hot-well $\frac{1}{4}$th the diameter of the discharge pipe.

Circulating Pumps.

The size of these depend chiefly on conditions mentioned for air-pumps, and they may bear a constant relation to the air-pump as to size, or to the L.P. cylinders.

Air-pump.	Circulating pump.	Ratio.
Single acting	Single acting	0·6
Single acting	Double acting	0·31
Double acting	Double acting	0·52

or if V = volume of cooling water in cable feet per minute
S = length of stroke in feet,
n = number of strokes (useful) per minute,
C = capacity of pump in cubic feet,
D = diameter of pump in inches;

$$C = \frac{V}{n},$$

$$D = 13{\cdot}55\sqrt{\frac{V}{nS}}.$$

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Circulating pump valves should be of sufficient area that the mean velocity of flow does not exceed 450ft. per minute. High velocities tend to wear out the valves, and cause undue resistance in the pump. In the suction and delivery pipes the velocity should not exceed 500ft. per minute, or for large and easy leads 600ft. per minute. Better results, however, will be obtained by using larger pipes so as to reduce the velocity, especially if the pipes are long. For single-acting pumps the suction may be smaller than the delivery, if the pump be below the water-level.

If a = minimum area through valves in square inches,
d = minimum diameter of pipe in inches,
A = area of pump in square inches,
D = diameter of pump in inches,
S = mean speed (useful) of pump in feet per minute;

$$a = \frac{A\,S}{450},$$

$$d = \frac{D\sqrt{S}}{K},$$

where K varies from 22 for small pumps to 25 for large pumps, while for the suction of single-acting pumps it may be 27.

Air vessels should always be fitted, which for single-acting pumps may be twice the capacity of the pump. An air-pipe should be fitted to the highest points of the water passages for escape of air to enable the condenser and pipes to run full. If the speed of the circulating pump cannot be varied independently, it is advisable to fit a water-valve between the two ends of the pump, so that the discharge may be varied to suit the requirements.

Centrifugal pumps may be used advantageously where the water is at the level of the pump. Some advantages are that if worked by an independent engine (as usual) the supply of cooling water can easily be varied, and the power required is reduced in proportion; the cooling water can be started before the main engines, so keeping the condenser cool; there is an absence of valves and shock to the condenser which there is not with reciprocating pumps. On the other hand, centrifugal pumps are more expensive and require rather more attention. Some of these advantages are obtainable by use of an independent reciprocating pump.

The inlet and discharge pipes should allow for a velocity not exceeding 400ft. per minute, while the diameter of the fan is two to three times that of the pipes. The peripheral speed of the fan must exceed 400ft. per minute, and is generally 450 to 500ft. per minute.

If V = cooling water in cubic feet per minute,
d = diameter of pipe in inches,
D = diameter of fan in inches,
B = breadth of blade in inches,
r = revolutions per minute of fan;

$$d = \sqrt{\frac{V}{2{\cdot}18}},$$

$$D = \frac{1{,}700}{r} \text{ or more},$$

$$B = \frac{V}{4{\cdot}7\,D}.$$

The fan should be of gun-metal, and the blades as thin as possible. The shaft should also be of gun-metal or cased with gun-metal.

Strainers should be fitted to the inlet of the suction pipe, and the aggregate area of the passages should be from two to four times the area of the pipe, according to the velocity of flow in the pipe. Owing to the difficulty experienced in cleaning strainers when under water, they are sometimes fixed in a cast-iron vessel near the suction entrances to the pump, with a door arranged in some convenient position for cleaning.

When the water level is below that of the pump a foot valve should be fitted just above the surface of the water. A door should be provided for examining the valve without disturbing the suction pipe.

Feed Pumps.

These should be of at least double the capacity found by calculation from the amount of water required for the engines, to allow for blowing off, leakage, slip in the pumps themselves, &c., and to enable the pump to keep down steam in case of sudden stoppage of the engines when the fires happen to be brisk. In addition, for all important plants there should be either a duplicate feed-pump or an injector to act as stand-by in case of accident. The speed of the plunger or piston may be 50ft. per minute, and should never exceed 100ft. per minute, else undue wear and tear of the valves result, and the efficiency is reduced. If the pump be required to stand idle without continually working, the plunger or piston and rod should be of brass.

In pumping hot water, the water must be above the level of the pump barrel.

If D = diameter of barrel in inches,
S = stroke in inches,
n = number of useful strokes per minute,
w = cubic feet of water pumped per hour,
W = lbs. of water pumped per hour;

$$w = 1{\cdot}7\,D^2Sn.$$

$$W = \frac{D^2\,Sn}{36{\cdot}6}.$$

If $Sn = 50$,

$$W = 1{\cdot}36\,D^2,$$

and

$$D = \sqrt{\frac{W}{1{\cdot}36}}.$$

The duty of pumps is expressed by the number of foot pounds of water raised per 100lb. of coal consumed in the boiler. "Low-duty" pumps give about 50 to 70 million, and "high-duty" 95 to 110 million or slightly above. With ordinary direct-acting pumps, where steam is maintained at initial pressure throughout, considerably less than a duty of 50 million pounds may be expected, especially with small pumps. A test made by one of the authors on such a feed pump gave but 21 millions foot pounds duty. It was also found at this test, which was made in feeding a 20 actual H.P. water-tube boiler driving an engine indicating 35 H.P., that 17 per cent. more coal was required when feeding with the feed-pump than when using an influx injector, although the feed-water was heated by the exhaust steam to 212°F. when using the pump.

By the use of a flywheel better results may be obtained, as the steam may be used expansively. Messrs. Worthington, in their high-duty pumps, use compensating water cylinders which oscillate so as to absorb power during the first part of the stroke, delivering the power during the second half; by this means they are able to work the steam expansively without the use of the complications introduced by the flywheel, and by adopting this system combined with compound cylinders they claim the highest duty.

The Brush Company make a three-throw feed-pump, which is geared to a high-speed engine with early cut-off, from which considerably more economical results may be expected. Arrangements are made for throwing out either one or two plungers to reduce the flow.

The feed-pump may be arranged to stop and start automatically by operating the steam valve on the pump by a float in the boiler. Feed non-return valves should have a diameter sufficient to allow of a lift not exceeding $\frac{1}{8}$in., to obviate the hammering action of the valve. Rubber valves may be used for cold water, but brass, rubber composition, or other suitable material is required for hot water or oil. If a new pump will not start, it may be due to imperfect connections or temporary stiffness of pump.

Unless the suction lift and and length of supply pipe be moderate, a foot-valve, a charging connection, and a vacuum chamber are desirable. The suction-pipe must be entirely free from air leakage. If the pump refuses to start lifting water with full pressure on, on account of the air in the pump chamber not being dislodged but only compressed each stroke, arrange for running without pressure until the air is expelled and water flows. This is done with a check-valve in the delivery-pipe, and a waste delivery which may be closed when water flows.

The annexed diagram shows an arrangement of connections suggested by Messrs. Worthington. B is the suction-branch,

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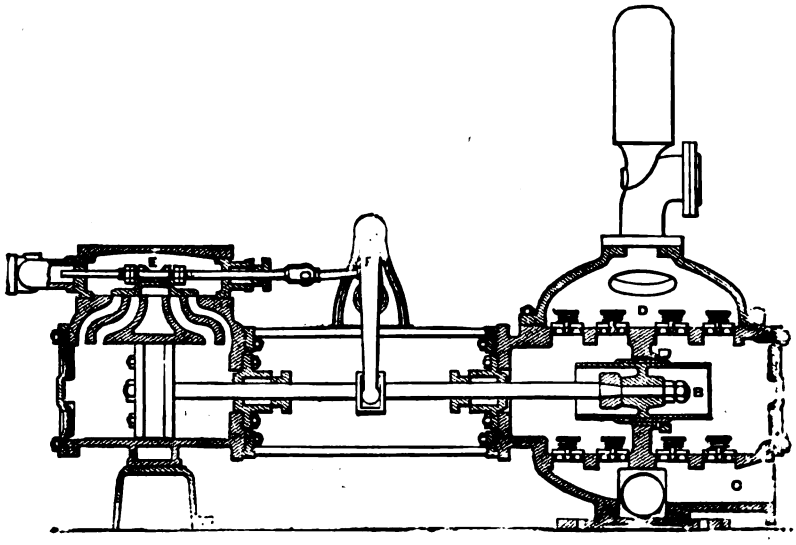
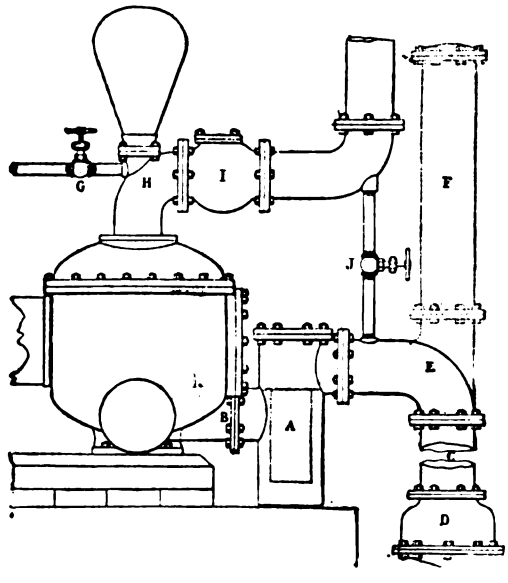
C is the suction-pipe, D is a foot-valve, F is a vacuum chamber necessary with long suction-pipes, A is a strainer which is more readily cleansed than when fixed at foot of suction-pipe under water, I is the delivery check-valve, G is a waste delivery or starting-pipe to free pump of air at starting, J is a charging-



Section of Worthington Feed Pump.



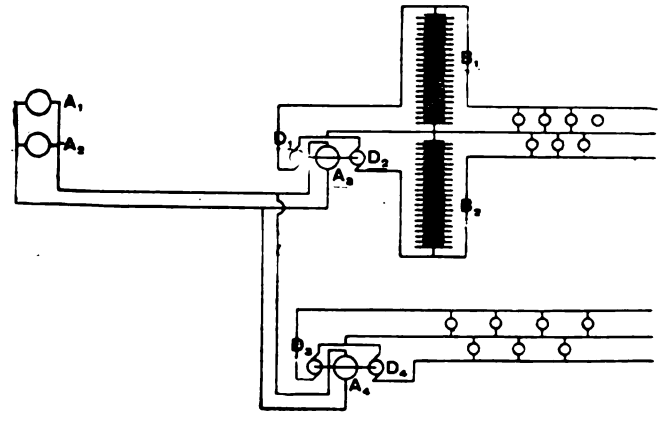
pipe for filling the pump chamber and suction-pipe from the delivery-pipe before starting.

POWER TRANSMISSION BY ALTERNATING CURRENT.*

BY GISBERT KAPP.

Some two years ago the municipal authorities of Cassel, in Germany, determined to become purveyors of electric light, and to place the generating station on the site of the waterworks pumping station, which is situated on the River Fulda, about four miles from the town. It would, of course, have been possible to lay down an ordinary alternating-current station, but this would not have been a good solution. In the first place, the total number of lamps that could have been installed would not have exceeded 2,500 of 16-c.p., corresponding with the maximum of 200 H.P. available at the pumping station; and in the second place, the low load factor of an alternating-current supply would have operated against the very object the municipality had in view, namely, to make the best use possible of their existing power plant. In order to carry out this object, it was obviously necessary to adopt some system of storage so that the turbines could work at full power continuously. With such a system the number of lamps installed could, at the same time, be materially increased. Thus, an ordinary direct-current station with batteries might have given these advantages, but for one, and that a very serious obstacle, namely, the great distance between the generating station and the town. It was evidently necessary to work at high-pressure and to use some system of transformation at a sub-station in the town; but high-pressure direct-current dynamos present difficulties which one would rather avoid than face, whilst the insulation of some 1,000 storage cells in series when charging, and their grouping in ten parallels of 100 and regulation whilst discharging present very serious difficulties and introduce complications. It wil thus be seen that neither the ordinary alternating-current system, nor the ordinary direct-current system with batteries, nor the so-called Chelsea system, presented a satisfactory solution of the problem involved in the lighting of Cassel. It was nevertheless solved in a very successful manner by a German engineer, Herr Oskar von Miller, who had been called in by the municipality to carry out the work. The plan adopted by von Miller was briefly this. He determined to transmit power by single-phase alternating current from the generating station to a sub-station or rather to two sub-stations in Cassel, and to use this power for the supply of direct-current on the three-wire system. At one of the sub-stations he established a battery which is charged during the hours of light load, and assists the dynamos during the hours of heavy load, so that the maximum power available shall suffice for 3,500 60-c.p. lamps wired.

The general arrangement of this installation is shown in the accompanying diagram:—A_1 A_2 are two 60-kilowatt alternators at the generating station. The current is transmitted through an underground concentric cable to the sub-stations. The alternators are designed for a terminal pressure of from 2,000 to 2,200 volts; and the loss in transmission, when both are working full power, is under 10 per cent. Each sub-station contains an alternating continuous-current transformer, consisting of a 60-kilowatt alternator,



A_3 A_4, coupled with two continuous-current dynamos, one on either side, D_1, D_2, and D_3, D_4 respectively. The latter machines are connected with each other and with the mains in the usual way adopted in three-wire distribution. At one of the sub-stations there is a battery, B_1 B_2, also arranged on the three-wire system. The mains throughout the district are coupled so that the battery sub-station can supply current to the other sub-station through the town mains. To start any one of the two transformers it is only necessary to switch on the two dynamos which begin to work as motors, and after observing by a synchroniser that the speed of the alternator has reached the required amount to close the high-pressure alternating-current switch when the alternator works as a motor supplying power to the two dynamos which are directly coupled to it.

It will thus be seen that not only are the two alternators at the generating station worked in parallel, but also the two sub-station alternators erected in different parts of the town are worked in parallel. The dynamos are Brown's design, and the alternators are of the type known under my name, both made by the Oerlikon Engineering Works, but I must distinctly state that I can claim no credit whatever for the Cassel installation; and that the whole credit for this (probably the earliest) example of power transmission by alternating currents is due to von Miller, who, at a time when most electricians were still in doubt as to the possibility of parallel running, boldly laid down a plant, the success of which was not only dependent on parallel running, but also on the economical and safe transmission of power by single-phase alternating current, using for this purpose the ordinary type of alternator as made for lightning. The plant was started on May 15th last year, and has been working since then without a hitch.

* Abstract of Paper read before the British Association, in Section G, Edinburgh, 1892.

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APPLICATION OF DESTRUCTORS, PARTICULARLY TO THE ELECTRIC LIGHTING OF EDINBURGH.*

BY PROF. GEORGE FORBES, F.R.S.

The object of this Paper, said the author, was to enable the citizens of Edinburgh to see the enormous natural advantages which exist in their city with relation to electric lighting. The advantages were such as would enable the people of Edinburgh to obtain the electric light at a price lower than gas, which could hardly be considered possible in any other town. First, as to the use of destructors, that was, the use of furnaces for burning the city ashbin refuse, which were recognised as the best way of getting rid of refuse, and the means of using these destructors for fuel to generate steam. Referring to any load diagram of an ordinary central station, they would find that during the greater part of the day the machinery and boilers were lying idle; for two hours only were they working at their maximum. To have these dynamos and engines standing without earning any money was very serious, but there was another serious result, and that was that the boilers required to be fixed up for simply a two hours' run. Every engineer knew what a low efficiency there would be from coal used in that manner. The only cure for this difficulty was some system of storage. The President of the Section had referred to the storage by means of hydraulic accumulators, which Lord Armstrong has so largely introduced; he has also alluded to storage—hydraulic storage in reservoirs—both at Geneva and Zurich. It was exactly following out those ideas that the author would suggest how the difficulty of storage should be overcome in Edinburgh. The reason why Edinburgh was peculiarly well situated was, that there was very high land in the immediate neighbourhood of the town—he referred specially to Arthur's Seat.

The author's first notion was to use Dunsapie Loch as a reservoir, the idea being that a steam-engine should be used at the low level, continually pumping water up to the high level, and at the lowest part of this, pipes and turbines should be attached for driving dynamos; this arrangement was exactly the same as that employed at Zurich. A further examination and consideration of the locality showed that by a slight additional expense they gained enormous advantages. Looking from the summit of Arthur's Seat, in the direction of Portobello, there was a gully which, by means of a very short dam, would enable them to make a reservoir which would not be in the least unsightly to the neighbourhood of Edinburgh, and, in fact, would be invisible save from the Portobello side of the hill. If such a dam were built, the pipe line would then be taken down to Lochend, nearly a mile distant. The height of the reservoir would be 725ft., and the height of Lochend 83ft.; they might also use Dunsapie Loch and St. Margaret Loch—in fact, there were several ways of doing the work. If Dunsapie were deepened to 10ft., it would contain a million and a-quarter cubic feet of water; but by building a dam near the summit of Arthur's Seat they got a quantity of water equal to 28,000 H.P. working for an hour, that is on the assumption of 75 per cent. efficiency on the turbines and pipes. The cost of the pipes carried from the summit of Arthur's Loch came out at the rate of £1 per horse-power. They would be able to see what could be done with this horse-power. The Berlin load curves showed that the maximum demand on a mid-winter day was four times the mean; secondly, if engines were constantly supplying power, storing what was not wanted, the storage capacity must be equal to maximum output working for about two hours; thirdly, the maximum output at any moment in the year was about six times the mean output of the whole year. Working from these facts, the author found that there can be obtained from the 28,800 H.P. hours available in the reservoir, a maximum output in the central station of 12,500 H.P., and that 3,000, continually working in the form of steam-engines, would make a total of 15,500 H.P. There is by this means saved the cost of 12,000 H.P. boilers and engines which would probably cost £200,000, replacing it by pipes and turbines, pumps and reservoir, probably costing not more than £35,000 altogether. Pumping engines and turbines were now so perfect that it would be possible to get a horse-power delivered from 3lb. of Welsh coal. Experience showed that, including the coal wasted in getting up steam and banking fires, even when using the best appliances of the modern central station, 5lb. of coal at least was required for every horse-power. There was then a saving of about 2lb. of coal per horse-power by keeping the engines working at their maximum. The maximum demand in winter was six times the mean of the year; thus, with a maximum of 15,625 H.P., there was a mean output of 2,600 H.P. all the year round. A saving of 2d. per lb. of coal per horse-power amounted to 20,000 tons, which at £1 per ton meant a saving of about £20,000 per year. These facts illustrated very clearly the enormous advantage of storage, which could be so easily gained by utilising the natural advantages of the City of Edinburgh.

The author then dwelt on the advantages of the use of destructors. There was no doubt that the use of destructors for getting rid of refuse, and for getting up steam for electric lighting purposes, would play an important part in the future, but in most towns it would be impossible to get the full advantage from the destructors, because they must be burning refuse day and night, whereas for electric lighting purposes, or the distribution of power, it was only during certain times of the day that there was a demand, so that the heat from the destructors was wasted for the greater part of the day; but by the hydraulic storage in Edinburgh they would be able to use destructors with the greatest advantage. After a reference to the destructor at Leeds, the author said that steam had not been largely used at Leeds, but at Southampton and one or two other places it had been largely used. At Southampton the boilers (locomotive) were simply placed in the main flues, without any attempt to drive the products of combustion through the flues, with the consequence that there was a very bad economy, and it required 75lb. of ashbin refuse to give a horse-power for one hour. The author had made numerous experiments on the heating properties of ashbin refuse, and there was not the slightest doubt that in the great majority of towns the ordinary ashbin refuse as a heat-producing power would mean that 10lb. would equal 1lb. of ordinary coal.

* Abstract of a Paper read before the British Association, in Section G, Edinburgh, August, 1892.

ON A NEW FORM OF GAS ENGINE.*

BY JOSEPH DAY, A.M.INST.C.E.

In this engine simplicity has been the principal object sought. The construction of the engine is as follows:—The piston is of the trunk form, and through a connecting rod works on to the crank pin. The crank works in an enclosed chamber, the crank shaft projecting through a boss bearing, terminating in a gland. On the upward stroke of the engine a partial vacuum is produced by the retreat of the piston, and this induces a flow of gas and air, in controlled proportions, into the crank chamber through an automatic valve. On the downward movement of the piston the mixture thus introduced is compressed—in practice, it is compressed to about 2lb. to the inch—and by this means is possessed of sufficient motive power to charge the working end of the cylinder. This is accomplished by the following device:—Communicating from the crank chamber to the lower part of the working end of the cylinder is a port or passage, and this is closed by the piston until the latter, at the end of its stroke, uncovers it. Immediately the gas mixture, being compressed as explained, flies up through the passage and charges the cylinder, the piston returns, closes the port, compresses the mixture in the usual way against an ignition tube, and an explosion results, causing the descent of the piston. The exhaust of the waste products is accomplished by the opening of a somewhat similar port communicating to the atmosphere *opposite* the inlet port above described, which is opened by the piston slightly in advance of the opening of the inlet port. Thus, when the incoming charge is admitted, the explosion in the cylinder has been reduced to atmospheric pressure. The incoming charge is made to assist in the clearance of the waste products by its being diverted upwards by a fin on the top of the piston, and thus setting up an eddying action, tending to drive out the contents of the cylinder through the open exhaust port. Thus it will be seen that with one piston and one cylinder an impulse is obtained at every revolution of the engine. It will also be apparent that the engine will run with equal facility and efficiency in either direction. The speed obtainable is very great, there being no tappets, cams, or levers, and in a small engine as much as 1,100 revolutions per minute have been obtained. At this speed firing was irregular, but at 500 revolutions the explosions were absolutely regular. For the same reason the engine runs extremely quietly. The writer claims to have produced an engine—(1) With fewer working parts than any other; (2) that occupies less space; (3) that without any alteration will run in either direction; (4) that, owing to the absence of friction, possesses a high degree of mechanical efficiency; (5) that runs more silently than any other gas engine.

* Abstract of a Paper read before the British Association in Section G, Edinburgh, August, 1892.

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"School of Mines Quarterly," Vol. XIII., No. 4. (New York: Columbia College.) Price 50 cents.

"Year Book of the Imperial Institute." (London: Imperial Institute.)

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SUMMER SCIENCE.

That any institution, however good its organisation, will eventually become obsolete is a matter so obvious as hardly to require comment. Its anachronisms may indeed be caused by the accurate appreciation by its founders of the immediate needs of their time, and by the adequacy of its functions in the past to supply a demand which either no longer exists or which exists in modified degree and in altered form. In the British Association, which was founded by Sir DAVID BREWSTER in 1881, the hopes of its originators have been signally fulfilled, in so far as the aim was the dissemination of miscellaneous science.

In the early days of the century which will so soon itself be a thing of the past, men had not learnt to look on science as the great force of the age; that which truly changes or tends to change the condition of rest or motion of human thought and affairs. It was a state of things as then unheard of to sit metaphorically and actually at the feet of a lecturer, expounding to his audience, in so far as their capability of comprehension allows, not only the known facts and discoveries of science, but exhibiting, with the shells of the hypothesis from which they sprung still adhering to them, the half-fledged notions of some leading thinker. As a promoter of scientific popularity much credit may be taken and much good has been done by the British Association. Its members are more than recruited yearly by those who take an intelligent interest in, although they may have no direct connection with, scientific bodies. It has gone far to prove the interest of the general public in investigations geographical, geological and otherwise; and no doubt has given a stimulus to

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the work of persons whose position lies between that of the amateur or dilettante scientist, and that of the "savant." It also gives an occasion for the great men whose departments rarely coalesce, and whose work approximates in no practical degree, to interchange ideas and have an opportunity of acquainting themselves by personal contact with their fellow workers. It enables the physicist to have the pleasure of hearing from the lips of a distinguished foreign biologist such sentences as this, "There are two reasons for this hypothesis; the first is that it is a good one, the second that we *must* have a hypothesis." Moreover, if we may judge from the last and one or two of its more recent gatherings, the British Association seems likely also to become a *rendezvous* for savants of other countries who in this way combine their own pleasure in the attractions of travel and of science, with the honour they confer on the town chosen for the meeting of the society.

But not wishing for a moment to undervalue these considerations, it seems a pity that the practical result of such an Association should be so unsatisfactory. Whether or no the advancement of knowledge in any great degree other than in the sense of rendering it popular, is furthered by those summer picnics, has long since ceased to exercise the scientific mind. There is a tacit understanding that the majority of the Papers will not contain the best and most serious work of their authors; in many cases the discussions are merely nominal, and we look in vain for evidence of that desire for members whose work shall not only be well up to the mark, but of real original value, which characterises another itinerant society, the Physiological. This society strives to exclude from membership all persons, however good in their general medical work, who are not of sufficient scientific eminence to merit the title of Physiologists. At present it occasionally happens at British Association meetings that a man exceedingly good in his own line, and who has been at some pains to be present at a Paper the subject of which is of interest to him, although outside his own work, is disconcerted by finding the reader of the Paper utterly incompetent to impart his knowledge in an intelligible and business-like manner, and having no apparent grasp of his subject. This sort of thing only serves to bring the society into disrepute. Another curious habit seems to be that local members are expected to contribute their share to the general mass of knowledge, and are pressed, sometimes against their will, to read Papers which they themselves are perfectly conscious of not containing very important or original matter, being, perhaps, the "remainder biscuits" of other Papers read on previous occasions, or before other societies.

Could the Association be reorganised in order to bring more into prominence its salient and social qualities, advantage would probably accrue to all therein concerned. Means of communication are now so enormously facilitated that one of the original aims of the institution is to some extent unnecessary. But were its potential uses more seriously taken into consideration it would have been less possible as in the present instance, for a large number of the local professors to fail with such unanimity in their duties, and to show such lamentable want of interest in the whole proceedings as to desert the town, dismally signalling their departure by the sheets of brown paper and domestic directions decorating their windows, leaving only persons but indirectly connected with the work of the Association to show hospitality to its members. The mechanism and organisation of the British Association are not in any degree so good or so complicated as to make remodelling undesirable; and no one taking into consideration the value of the work done could doubt the wisdom of its members were they honestly to face the position of their body in the scientific world, and having come to some conclusion boldly to assert its right to exist, either by improving it as a practical working body, by making its work more serious, and its dilettante members less welcome; or by resting its value candidly on the, perhaps, not less useful standpoint of social intercourse. With some such remodelment as this there would be no danger of the summer meetings coming to an end. For the desire of hearing something new springs eternal in the human breast; and those workers who are enthusiasts and whose pleasure lies largely within their work, or in subjects bearing on their studies, would have the attraction of a holiday which combined a necessary change of air with an opportunity of interchanging stimulating ideas with their contemporaries.

GEARING.

BY E. TREMLETT CARTER.

In this series of articles the term "gearing" will be applied to all those combinations of mechanical parts which are intercepted between a motor, such as a steam engine or electromotor, and the work it has to do. The necessity for such mechanism arises from the unsuitability of the engine to being directly applied to the machine which has to do the work; either on account of their differences of speed, or because of the inconvenient position of the machine, or on account of the necessity to subdivide the power of the engine so that it may drive more than one machine. In the case of an engine driving a single dynamo the necessity for gearing arises from a species of incompatibility between the two; and since it is both expensive and wasteful of power it is to be avoided wherever possible. Gearing, therefore, must be looked upon as an evil by generating station engineers, an evil which should be eliminated by adapting the designs of engines and dynamos so that they will run together without it. But there are many cases in which an electrical engineer is compelled to use some form of gearing; in tramway work, in lighting installations run from a factory engine or countershaft, and in temporary work; and it may be of some use to discuss the relative merits, and to give some simple rules for designing the ordinary forms of gearing.

Gearing may be conveniently classified under two heads:—(1) Force-closure gearing, in which the power is transmitted through machine parts held in relative position by friction; and (2) pair-closure gearing, in which the parts are held together by the strength or molecular resistances of interlocked pieces. The relative merits of these two forms of gearing may be summed up in a few words. Friction, or force-closure gear, is very smooth running, silent, free from vibration, and has a tendency to destroy any severe shocks developed in the engine; as, when any such shock occurs, slipping takes place and the machine is almost unaffected; but it does not maintain a constant velocity-ratio between the engine and the machine, and on this account cannot be used where very accurate motions have to be transmitted. Moreover, owing to its tendency to slipping, and inability to prevent the machine driving the engine backwards, it cannot be used in such cases as tramway work, or for elevators. Pair-closure gear possesses the exact opposite of all these qualities; it is noisy and full of unpleasant vibrations; it cannot slip, and every irregularity of the engine is transmitted unaltered to the machine.

Belting.

Belting is a common form of friction gear. A strap or flat belt is passed over the flat or slightly convex faces of two pulleys, placed one on each shaft, and called the driver and follower respectively. Owing to the weight of the belt and the small sag that is allowed in the free portions, the belt, when not

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running, is under a considerable tension, which has practically the same value in every part. This tension causes a pressure of the belt on every part of the arcs of contact with the pulleys, and this pressure causes everywhere a frictional resistance to slipping of the belt on the pulleys, which is equal to product of the pressure into the coefficient of friction between the belt and the metal of the rims. Now the pressure of the belt on the pulleys is not the same at all parts of the arc of contact, so that the total frictional resistance must be obtained by integration. In Fig. 1 let $d\phi$ represent a small element of the angle of contact, T the tension in the belt at that part, R the

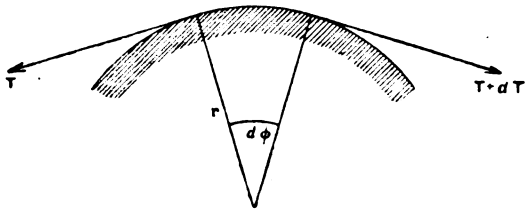

FIG. 1.

normal pressure on the element, and P the normal pressure per square inch on the element. Then, by the parallelogram of forces,

$$R = 2 \cdot T \cdot \sin \cdot \frac{d\phi}{2} = T \cdot d\phi,$$

also $$R = P \cdot b \cdot r \cdot d\phi,$$

where b and r are the breadth of the belt and the radius of the arc respectively. Therefore,

$$P \cdot b \cdot r \cdot d\phi = T \cdot d\phi,$$

$$P = \frac{T}{r \cdot b}.$$

If this normal pressure is multiplied by the coefficient of friction μ, the frictional resistance per square inch of belt at this point will be obtained; and this again multiplied by the surface of the element, $b \cdot r \cdot d\phi$, will give the actual frictional resistance of this element. Now, this resistance will oppose a difference in tensions between the two ends of the element which will be equal to the frictional grip of the element. Calling the difference in tensions which can thus be set up without slipping taking place, dT, we then have

$$dT = \mu \cdot P \cdot b \cdot r \cdot d\phi = \mu \cdot T \cdot d\phi,$$

whence integrating we get

$$\int_{T_1}^{T_2} \frac{dT}{T} = \mu \cdot \int_{0}^{\phi} d\phi.$$

$$\therefore \log_{\epsilon} \frac{T_2}{T_1} = \mu \cdot \phi,$$

or $$\frac{T_2}{T_1} = \epsilon^{\mu\phi}.$$

This gives the ratio between the tight and slack tensions, T_2 and T_1, which may be applied at opposite ends of the arc of

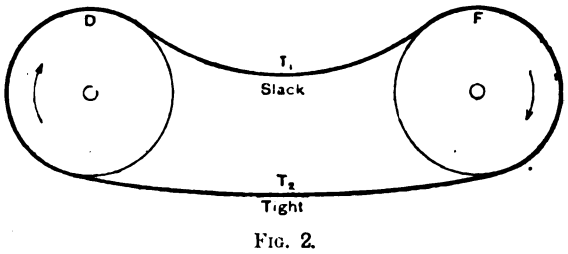

FIG. 2.

contact before slipping can occur. It will be seen that a large arc of contact and a high coefficient of friction are desirable.

In Fig. 2, let D be the driving pulley and F the following pulley. Suppose F clamped so that it cannot move, and a torque applied to D, then D will turn round, and as it does so it will increase the tension on one side and reduce it on the other side of the free belt. This difference in tension will cause a torque to be applied to F equal to

$$(T_2 - T_1) \times \text{radius of F.}$$

When T_2 is in the ratio of T_1 indicated by the exponential formula, the belt will slip on that pulley on which it has the smallest arc of contact. Suppose, however, that the torsional resistance of F is not sufficient to allow the tensions to exceed these limits, then the difference in tensions will go on increasing till the torque set up on F is equal to the torsional resistance which it opposes; at this point F will commence to turn and power will be transmitted from D to F. The amount of power transmitted will be,

$$\text{H.P.} = \frac{(T_2 - T_1)\,V}{33{,}000}.$$

Where V is the velocity of the belt in feet per minute.

The material most commonly used for flat belting is leather; although canvas and rubber, cotton, and even paper pulp have been employed. We can afford space, however, to consider only ordinary solid leather belting. On turned cast-iron or wrought-iron pulleys this material has a coefficient of friction of about 0·4 if not oily, but when the belt is allowed to get oily this is reduced to about 0·2 or 0·3. The arc of contact depends on the relative diameters of the pulleys, on their centre distance, on the tightness of the belt, and whether it is crossed or open, as well as on the direction of driving. It is always advisable, where possible, to drive with the tight part of the belt on the lower side, as shown in Fig. 2, for this makes the slack part sit down on the pulleys, and thus increases the arcs of contact. Crossed belts should be avoided where steady driving is necessary, and are only to be employed where reversed motions are required. With open belts at the proper centre distance between pulleys, the ratio of working tensions may safely be raised to 2, the rule being to make the arc of contact on the smaller pulley *not less* than 40 per cent. of its circumference.

The safe stress per square inch of solid leather belt, allowing for reduction of strength due to lacing, rivetting or cementing, may be taken at 320lb., and this is equal to a maximum tension of 20lb. per inch width for every sixteenth of an inch thickness. With these data we may proceed to design the belt to transmit a given horse power:

$$(T_2 - T_1)V = 33{,}000 \text{ H.P.}$$

And $$T_1 = \tfrac{1}{2} T_2$$

Whence, $$T_2 = \frac{66{,}000 \text{ H.P.}}{V}$$

Also, $$T_2 = 320 . b . t$$

where b and t are the breadth and thickness in inches. Consequently, $$b \cdot t = \frac{206{\cdot}25 \text{ H.P.}}{V}$$

The proportion between b and t will be decided by the considerations that if the belt is made very thick much power is wasted in continually bending fresh portions of it over the pulleys, while if it is too thin and wide the pulleys will be large, heavy, and expensive. The waste of power on account of the stiffness of the belt varies as the square of its thickness and as its breadth. Belts of moderate size are usually from 16 to 25 times their thickness in width. As to the best value for the velocity of the belt, it must be remembered that too low a speed will entail a heavy and expensive belt, while too high a speed will increase the loss of power and the depreciation, and will put an unnecessary strain on the belt on account of centrifugal action. There is a certain speed at which it is most economical to work a leather belt, and that speed lies somewhere between 2,500 and 3,000ft. per minute. The latter is a very common figure for machine belts, while engine belts are usually run slower. Slow-speed engines of moderate power often run belts as slowly as 1,000ft. per minute, owing to the fact that a higher speed would involve too large a diameter of pulley; but these excessively low speeds are not to be recommended. With very large power to be transmitted, the belt becomes so thick and wide that it is a serious source of loss of power. It is not well to use leather belting for dynamo work

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where more than 80 or 100 H.P. is to be transmitted. In such cases ropes are more economical of power, though they take up more floor space. The saving in power more than compensates for the extra cost of floor space.

Table *of the Greatest Ratios of the Tight to the Slack Tensions.*

Values of ϕ in degrees.	Values of μ=							
	0·15	0·20	0·25	0·30	0·35	0·40	0·45	0·50
90	1·26	1·37	1·48	1·60	1·73	1·87	2·05	2·19
100	1·29	1·40	1·52	1·66	1·81	1·97	2·15	2·34
110	1·33	1·46	1·60	1·76	1·94	2·14	2·35	2·59
120	1·35	1·50	1·66	1·83	2·03	2·25	2·49	2·76
130	1·39	1·55	1·73	1·93	2·16	2·41	2·69	3·00
140	1·42	1·61	1·80	2·02	2·28	2·56	2·91	3·24
150	1·47	1·68	1·91	2·18	2·48	2·83	3·22	3·78
160	1·51	1·74	2·00	2·30	2·64	3·04	3·49	4·01
170	1·54	1·81	2·09	2·38	2·82	3·28	3·70	4·41
180	1·60	1·87	2·19	2·50	3·00	3·51	3·97	4·80
190	1·65	1·94	2·29	2·70	3·20	3·77	4·45	5·26
200	1·69	2·01	2·39	2·85	3·40	4·05	4·83	5·76

The ratios of tensions given in the above table indicate the points at which the tensions are sufficient to cause continual slipping of the belt over the pulley; in practice, the ratio of tensions in a belt should not exceed 60 per cent. of the figure supplied by the table. The following table gives the amount of horse-power transmitted by one square inch section of solid leather belt under these safe conditions, when running at 1,000 feet per minute:—

Table *giving the Horse-power Transmitted per square inch Section of Solid Leather Belting at 1,000ft. per minute, with Different Arcs of Contact and Different Amounts of Friction.*

Values of ϕ in degrees.	Values of μ.							
	0·15	0·20	0·25	0·30	0·35	0·40	0·45	0·50
	Horse-power per square inch of section of belt.							
90	1·2	1·6	1·9	2·3	2·5	2·8	3·1	3·2
100	1·3	1·7	2·0	2·4	2·6	2·9	3·2	3·4
110	1·4	1·8	2·2	2·5	2·8	3·1	3·4	3·7
120	1·6	1·9	2·3	2·6	2·9	3·2	3·5	3·8
130	1·7	2·1	2·5	2·8	3·2	3·5	3·7	4·0
140	1·8	2·3	2·7	2·9	3·4	3·7	3·9	4·1
150	1·9	2·4	2·8	3·1	3·5	3·8	4·1	4·3
160	2·0	2·5	2·9	3·4	3·7	4·0	4·2	4·4
170	2·1	2·6	3·1	3·5	3·8	4·1	4·3	4·5
180	2·2	2·8	3·2	3·6	3·9	4·2	4·4	4·6
190	2·3	2·9	3·3	3·7	4·0	4·3	4·6	4·7
200	2·4	3·0	3·5	3·9	4·2	4·4	4·7	4·9

The above table is correct for velocities between 1,000 and 4,000 feet per minute if the following rule is adopted: Multiply the figure given in the table by the section of the belt in square inches, and by the velocity of the belt in feet per minute, and divide by 1,000; the result is the horse-power transmitted by the belt. To find the section of belt required to transmit any given horse-power, multiply the horse-power by 1,000 and divide by the product of the velocity of the belt into the figure given by the table; the result is the section in square inches.

Belt joints for electric-light work must be carefully made, with a view to strength and uniform running over the dynamo pulley. The ends should always be cut off square with a sharp knife, using a set-square, and not guessing with the eye. The holes should be carefully and cleanly punched out with a small round punch, and not wriggled out irregularly with a bradawl, or they will be liable to be torn by the rivets. The joints are either rivetted, laced, or cemented, the ends being lapped over one another, or fastened by means of a cover strap of leather of the same thickness and width as the belt, and about 15in. to 18in. long. The butt joint, with a cover strap, works more smoothly than an ordinary lap-joint; but the best joint is made by scarfing the ends of belt to a gentle taper, cementing them into a lap-joint of uniform thickness, and rivetting through with countersunk-headed copper rivets, at the rate of one rivet per 4 square inches of lap. Unfortunately this joint cannot be taken apart in order to shorten the belt when it has slacked out with wear; and it is thus necessary to have one joint of the ordinary butt-strap form. Rivets should be distributed over the strap at the rate of $2\frac{1}{2}$ to 3 square inches per rivet. The slack which develops in a belt soon after it is put on the pulleys is usually "taken up" by means of rails, the dynamo being moved along these rails, so as to tighten the belt, by means of screws. When a lot of slack has thus accumulated it is usually cut out of the belt at one of the joints, and the dynamo run forward to the front end of the rails again. It is always well to examine belt joints a short time before commencing to run the machinery. "A stitch in time saves nine," and a little attention before starting will often save the inconvenience and disappointment of a breakdown when the machinery is most required.

Belt pulleys are usually of turned cast-iron or wrought-iron plate; but for high-speed belting cast steel pulleys must be used. The face of cast-iron pulleys is convex, having a radius of curvature of about four times the width; wrought-iron pulleys are sometimes formed of dished plate, so as to give the face this curvature, but are more commonly flat. The advantage of the curvature is that it helps the belt to ride on to the middle of the pulley face if it should get displaced towards the edge, and thus tends to prevent the belt slipping off the pulley. Cast-iron pulleys are heavier than wrought-iron, but run with truer surfaces, owing to the fact that they are turned up to centre after casting. Cast iron is, however, a very unreliable metal under the stresses to which pulleys are subjected, and must on no account be run with a higher rim-velocity than 80ft. per second. Pulleys and other machine details of this metal should on no account be hammered, as it is very brittle. The arms of cast-iron pulleys are usually a single or double curve, with gradual contraction of section from the point where they join the rim. The object of these elements of design is to reduce the internal stresses which are set up when the metal cools after casting. Sudden contraction of section, sharp angles, and straight spokes, or arms, are always to be avoided in iron castings. Wrought-iron pulleys are tougher and less liable to fly to pieces than cast-iron. The rivets are the weakest parts as a rule, and when a wrought-iron pulley bursts it gives out at the joints, but is still held by the shaft. When the peripheral velocity is very high, belt pulleys are found to work more satisfactorily if the face is perforated with a number of small circular holes. This enables the belt to get a firmer grip of the pulley, as the film of air which otherwise separates the former from the latter is able to escape through these holes.

The diameter of the pulley is chosen with respect to the speed of the belt, and the number of revolutions per minute required on the shaft. If the belt speed is divided by the revolutions required, the quotient is the circumference of the pulley. It is not usual to make any correction for the thickness of the belt, except when the pulley diameter is not very large in comparison. If this correction is desirable, the real diameter of the pulley can be obtained from the rough rule given above, by subtracting the belt thickness from the diameter which that rule gives. The pulley width is best calculated from the following equation:—

$$w = 1\tfrac{1}{3}\ (b + \tfrac{1}{2}),$$

Where w is the width in inches, and b the breadth of the belt.

The centre distance between pulleys should be selected with a view to getting a good arc of contact on each pulley, and a weight of belt freely suspended sufficient to give the requisite tension in the belt. When a large pulley drives a very small one, therefore, the centre distance should be greater than in the case of two pulleys of equal size. When the portions of the belt between pulleys are freely suspended, it is not advisable to allow a less distance than 10ft. between centres, while it will generally be found necessary to have at least 15ft. for steady driving with pulleys of nearly the same size, or when one is not less than one-quarter the other, and from 15ft. to 20ft. when there is a greater difference between the diameters. Where it is necessary to have a compact plant, and such long centre distances are out of the question, if belting is to be used (though it would be better to adopt some other form of gear), jockey

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pulleys must be used. These are idle pulleys, so placed that they force the belt to make a large arc of contact on the pulleys even with the minimum of space between the pulleys. Fig. 3 shows an arrangement of jockey pulleys as used for a ship lighting plant. The slack can be taken up by turning a handle which causes the jockey pulleys to approach one another.

Example.—*A dynamo requiring 50 H.P. at 400 revolutions per minute has to be run from a line of countershafting making 200 revolutions per minute. Design the belt gearing.*

Roughly estimating we find that with ordinary velocities of belt the diameter of the dynamo pulley would be about two feet. We take this figure, and find that the belt velocity will be 2,514ft. per minute. The diameter of the pulley on the countershaft will be 4ft. The maximum tension on the belt when running will be 1,320lb. Taking solid leather belting at 320lb. per square inch working tension, the section of the belt works out to $4\frac{1}{8}$ sq. in. Owing to the small diameter of the dynamo pulley we should hesitate to put on a belt of greater thickness than $\frac{5}{16}$in., which gives a width of $13\frac{1}{4}$in. If this seems too wide, we might take the smallest thickness of double belting—though the pulley is rather too small for it—and the size of belt would then work out to 11in. wide and $\frac{3}{8}$in. thick. The choice lies between a wide belt $13\frac{1}{4}$ by $\frac{5}{16}$ and a thick one 11 by $\frac{3}{8}$in.

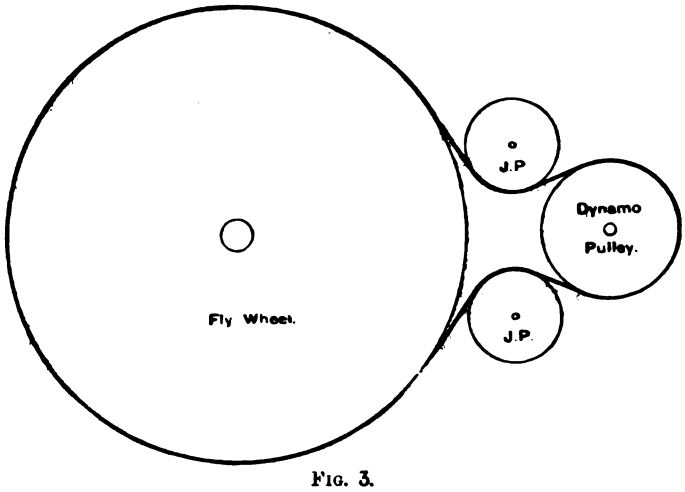

Fig. 3.

It would be advisable to have a centre distance not less than 15ft.

(To be continued.)

A CONTRIBUTION TO THE THEORY OF THE PERFECT INFLUENCE MACHINE.*

BY J. GRAY, B.SC.

The history of the development of the heat engine appears to have repeated itself very closely in that of the electrical influence machine. The early experimental gropings of Savary and Newcomen with the steam engine run parallel with those of Darwin, Nicholson, and others with the influence machine, resulting, in both cases, in machines certain, indeed, in their action, but, from ignorance of principles, very inefficient in their design. A close study of the working of the steam engine and the application of higher principles by the genius of James Watt produced a machine of much greater efficiency, and left little to be done by his successors except the perfecting of details, till another great advance was made in the theory of the heat engine. The labours of Holtz, extending over a period of twenty years, during which he worked out and perfected in detail almost all the leading types now in use, have earned for him a good claim to be considered the Watt of the electrical influence machine. The third stage in the development of the heat engine coincides with the rise in the science of thermodynamics. The investigations of Carnot, Thomson, Rankine and others showed that the heat cycle through which a mass of working fluid must pass in order to give a maximum efficiency must be represented by adiabatic and isothermal lines only. This principle has been applied to the influence machine by Maxwell, who showed that equiquantic and equipotential lines must form in this machine the perfect cycle.

The object of this Paper is to describe some graphic methods which I think help to elucidate the action of Maxwell's machine, and also to show by what amount the efficiency of the influence machine may be increased by the application of Maxwell's principles.

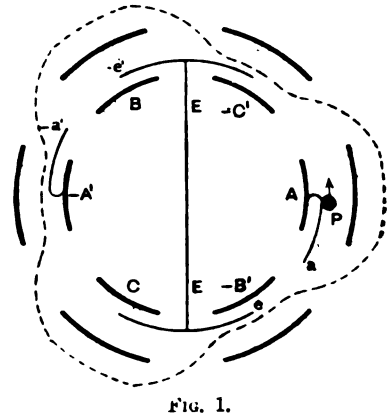

Fig. 1.

Maxwell points out that, over and above the loss from leakage, there is a loss of energy through the sparking which takes place just before a carrier makes contact with the charging or discharging points in its course. The energy lost in each spark is $\frac{1}{2}$ Q V; Q being the quantity of electricity transferred, and V the difference of potential producing the spark. The object of his invention is to do away with sparking. He effects this by causing the carrier of electricity to make contact with charging and discharging springs when its potential is the same as that of the spring in question, and to remain in contact during the whole time of charge or discharge.

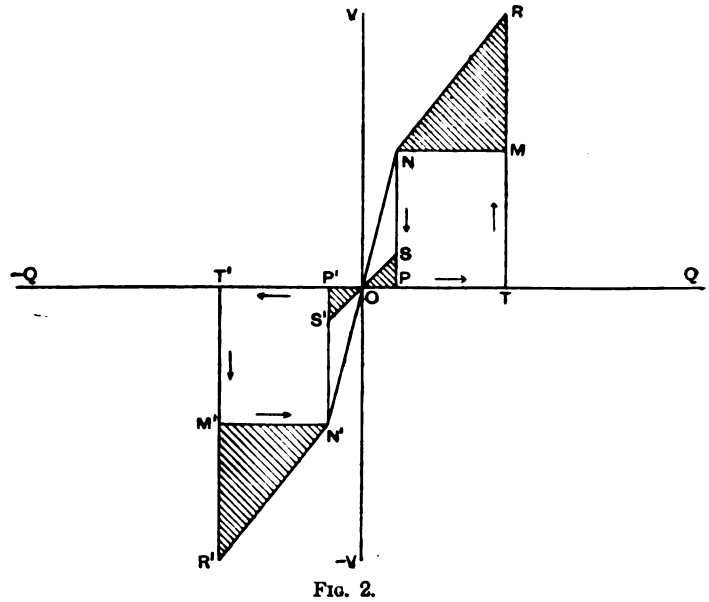

Fig. 2.

Fig. 1 is a diagram which will serve to show the action of Maxwell's machine. In this diagram conductors are represented by black lines, &c., and insulators are left white; a convention in agreement with the electromagnetic theory of light, according to which these bodies are respectively opaque and transparent. The machine consists of six fixed hollow conductors, A, B, C, A', B', C', which may be looked upon as six sections of a hollow anchor ring, separated by insulating air spaces. A conducting carrier P is caused to revolve through the centre of the hollow conductors in the direction shown by the arrow. Three of the

* Paper read before the British Association, in Section A, Edinburgh, August, 1892.

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conductors A B C are connected to a Leyden jar of large capacity charged to a positive potential V; the other three conductors A′, B′, C′ are connected to another similar Leyden jar charged to a negative potential – V.

The conductors taken in order round the ring are thus alternately positive and negative. The dotted line on the diagram is drawn to represent approximately the potential at each point of the circular path through the centre of the conductors along which the carrier P travels. The potential at each point is indicated by the distance of the dotted line from the outer circle of the diagram. To the conductors A and A′ are connected contact springs a and a'; and lying partly inside the conductors B and C′ is a spring e' connected to earth, or a similar spring e lying partly within the conductors B′ and C.

The changes in the energy of the carrier P during one complete revolution and the work done upon it, I propose to show by a Q V diagram, *i.e.* an energy or work diagram, in which the components are the quantity and the potential of the carrier. Let Q O Q, V O V (Fig 2) be the axes of co-ordinates; distances along O Q representing quantities of electricity on the carrier, and distances along O V representing potentials of the carrier. We shall start with the carrier P as represented in Fig. 1, just about to break contact with the spring a which is connected to the conductor A. The potential of the carrier will be equal to that of A, which we will represent by an ordinate P N (Fig. 2). Its quantity, due to its not being completely surrounded by the conductor A, may be represented by O P. As O P = V tan P N O, tan P N O will represent the capacity of P with reference to the earth. Let tan P N O = α. The point N on Fig. 2 corresponds therefore to the position of P on Fig. 1. In passing from its initial position till it comes in contact with the earth spring e' inside the conductor C′, P retains its quantity unchanged. We will suppose that S P represents the potential of P when about to make contact with the earth spring, if the conductor C′ were removed. In order to reduce the potential of P to zero when it makes contact, the inductive effect of C′ must be such as to produce an equal and opposite quantity to O P on the carrier P. Therefore,

$$C' = \frac{O P}{V} = \frac{\alpha V}{V} = \alpha$$

is the equation for determining C′, the coefficient of induction of the conductor C′ upon the carrier P.

The state of the carrier is now represented by the point P on Fig. 2. The passage of the carrier along the spring e' is represented on Fig. 2 by the line P T′, corresponding to a gradual loss of electricity at zero potential till it finally leaves the spring with a negative charge represented by O T′. From contact with the spring e' to contact with the spring a' the quantity remains constant but the potential falls, *i.e.* we pass from T′ to M′ on Fig. 2. Along the spring a' the quantity increases positively (or decreases negatively) at constant potential – V; *i.e.* passes from M′ to N′ on fig. 2. The spring a', of course, must be of such a length as to meet the carrier when it is at the same potential as A′. This completes one half of a revolution, and the other half is exactly similar though opposite, namely along N′ P′ T M N to the starting point.

The work done on the carrier in one revolution is equal to twice the area of the rectangle N T. A quantity P T of positive electricity is imparted to the conductor A, and an equal quantity of negative to the conductor A′, the potentials being V and – V respectively.

The efficiency of the machine in such a cycle is *unity*, that is to say there is no loss, supposing friction, leakage, &c. to be absent. The quantity of electricity produced per revolution is less than the maximum possible by the amount left on P when it leaves the discharging conductors A or A′. The conductors C and C′ are called by Maxwell regenerators, because their function is similar to the regenerator in the heat engine.

Let us now in the first place consider how much the efficiency of the machine is reduced by the removal of the regenerators. The effect of removing C′ will be to allow the carrier P to spark to the spring e' before making contact, and the energy dissipated in this spark is equal to the area of the triangle S P O, if the inductive effect of A and B on P is negligible. There is a similar loss in the other half of the revolution. The efficiency will now be

$$E = \frac{Q V}{Q V + \frac{1}{2}\alpha V . S P.} = \frac{Q}{Q + \frac{1}{2}\alpha S P}$$

This efficiency approaches to unity as α or S P approaches zero, and α can always be made very small by extending the discharging conductor and bringing it very close to the carrier.

Let us now, in the second place, consider the loss of efficiency due to replacing the long contact springs a and a' by contact points inside the conductors A and A′. On approaching and entering A the potential of P will not stop at M (fig. 2), but will rise to R before discharge. If α is very small, and the conductors B′ and A similar and equal, M R will be very nearly equal to M T. The energy dissipated in the spark is equal to the area of the triangle R M N. The efficiency in this case would be—

$$E = \frac{1}{1\frac{1}{2}} = \frac{2}{3}.$$

The absence of long contacts in the discharges thus leads to a much greater loss of efficiency than the absence of the regenerators.

Thirdly, if the long contacts e and e' are replaced by point contacts at the centres of the conductors B and B′, the energy dissipated per cycle is equal to the area of the triangle P N T′. The efficiency

$$E = \frac{1}{1\frac{1}{2} + \frac{\alpha V}{Q}} < \frac{2}{3}$$

Finally, when all the contacts are points, as in the ordinary influence machine, the efficiency,

$$E = \frac{1}{2 + \frac{\alpha V}{Q}} < \frac{1}{2}$$

All these results can be obtained readily by inspection from the diagram Fig. 2.

I have made a machine with long contacts but without regenerators, which is self-exciting, and gives considerable quantity; but owing to difficulties of insulation, which I hope soon to overcome, I have not been able to get long sparks. These graphic methods may be applied to any influence machine for investigating their theoretical efficiency.

ON PRIMARY AND SECONDARY BATTERIES IN WHICH THE ELECTROLYTE IS A GAS.*

BY PROF. ARTHUR SCHUSTER, F.R.S.

If a current of electricity passes through a vessel which is partially exhausted the whole gas contained in the vessel becomes a conductor in the ordinary sense, and a single cell will send a measurable current through it. This phenomenon, which may conveniently be called "secondary conduction," has been investigated by the author and Prof. Arrhenius. A more detailed study during the past year has brought some interesting phenomena to light. If the secondary electrodes are platinum and the gas is a hydrocarbon, phenomena of polarisation are observed exactly similar to those found when water is decomposed. The electromotive force of polarisation in that case amounts to about 3 or 4 volts. No polarisation or traces only are found with hydrogen, oxygen, nitrogen, cyanogen, aqueous vapour, ammonia, and other gases experimented upon; but phosphoretted hydrogen shows the phenomenon. When the electrodes are made of copper or iron no polarisation is observed in hydro-carbons; on the other hand, when aluminium or magnesium are used, it rises to very high values. Magnesium electrodes, in which the secondary current from 30 Clark cells was allowed to pass for some time, showed a polarisation of 35 volts. The polarisation effects are

* Abstract of a Paper read before the British Association in Section A Edinburgh, August, 1892.

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studied just as in the case of liquids by interrupting the polarising current and connecting the secondary electrodes with a galvanometer or electrometer. When a hydrocarbon is used both electrodes become covered with a thin film, which shows the colours of thin layers of metallic oxides or sulphites. The fact that the electromotive force depends so much on the nature of the metal tends to show that a metallic carbon compound is formed by the action of the primary current, and that the effects are analogous to those of the secondary battery.

The author has also studied the currents observed when electrodes of different metals are inserted into a gas rendered sensitive by the electric discharge. Arrhenius had already shown that zinc and platinum in air give a permanent difference of potential under these circumstances. The author finds that whatever the gas which has been converted into a conductor by a primary discharge, permanent currents may be obtained from magnesium and platinum electrodes, the magnesium always being electro-negative. The electromotive force is, however, different in different gases, and higher for instance in oxygen than in hydrogen.

ON CERTAIN VOLUME EFFECTS OF MAGNETISATION.*

BY PROF. CARGILL G. KNOTT, D.SC., F.R.S.E.

The experiments had to do with the changes of the internal capacity of five iron and five steel tubes, each set having been cut from the same bar and bored to various bores. All had the same length, 18in., and the same external diameter, 1½in. The iron tubes were distinguished by the Roman numerals I. to V.; and the steel tubes by the corresponding Indian numerals 1 to 5. Tubes of the same number had equal bores. Thus the internal diameter of Nos. I. and 1 was 1¼in.; of Nos. II. and 2, 1in.; and so on to Nos. V. and 5, which had each an internal diameter of ¼in. Each tube was closed below. When set up for experiment it was closed above by a screw nut through which a capillary glass tube passed, and was then placed vertically in the heart of the magnetising coil. The whole of the metal tube and part of the capillary were filled with water, and the changes of internal volume were measured by the motion of the liquid meniscus in the capillary. In strong fields this motion was easily seen by the naked eye. It was shown at the meeting projected by the lantern on the screen. The measurements were made by means of a micrometer microscope.

The observed changes of volume amounted in some cases to nearly 5×10^{-4} cubic centimetres; and in the narrower-bored and thicker-walled tubes it was evident that higher fields than those used would have produced still greater volume changes. The highest field that could be safely used was 1,400 C.-G.-S. units.

The general characteristics may be briefly described thus. In Nos. I., 1 and 2, the effects were very similar, differing only in detail. In low fields the capacity was diminished, in high fields increased. In other words, the graph showing the relation between magnetising force and change of volume began by passing under the line of zero change, then crossed it and continued thereafter above it. In Nos. II. and III. a similar *form* of graph was obtained, only it did not reach the zero line after the maximum decrease was passed. In these cases, as in the case of No. IV., the capacity was always diminished. No. 3 showed increase of capacity in all fields from the lowest to the highest. Nos. 4 and 5 began by showing increase in low fields, but in fields higher than 200 units showed decrease of capacity. A similar but less marked effect was obtained with No. V.; in other words, the graphs of Nos. 4, 5 and V. passed first above the zero line, then cut through it, and passed in almost rectilinear course below it, continuing so to the highest fields attained. The following scheme gives the nature of these changes, *minus* meaning a diminution of bore, *i.e.*, an average contraction of the walls of the tube as a whole, and *plus* an increase of bore or average expansion. By low fields we mean fields of less than 200 units. The numbers are the greatest measured values of the dilatations, or changes per unit volume, and are maximum or minimum values in all the low fields except in the case of No. 3 and No. IV.

Increase of Capacity (in 10^{-5} cubic cm.) of Iron and Steel Tubes.

—	Iron tubes.		—	Steel tubes.	
Nos.	Low field.	High field.	Nos.	Low field.	High field.
I.	−17	+11	1	−19	+42
II.	−19	− 6	2	−12	+15
III.	−25	−26	3	+12	+40
IV.	−14	−51	4	+2·4	−41
V.	+0·5	−32	5	+2·3	−13

The greatest *change per unit volume* was obtained in the case of tube 4. In field 1,000 the dilatation amounted to -4×10^{-6}.

It was necessary to subject the tube to each magnetic field taken first in one direction and then in the other. If this precaution were not taken, the material got into a state of magnetic bias. Very interesting results were obtained when a smaller field was applied after a greater field, the magnetic bias, or "after-effect," due to the larger field having a very pronounced influence. To get rid of this magnetic bias it was sufficient to neutralise the tube by subjecting it to a series of fields of diminishing intensity and alternating direction.

ON THE DIELECTRIC OF CONDENSERS.*

BY W. H. PREECE, F.R.S.

Artificial cables are very useful adjuncts to the laboratory of the telegraph engineer. They not only enable him to experiment at his leisure, but they form very useful means to test and compare high-speed and delicate telegraph apparatus, and especially telephones. I have one, made some years ago, which has been in incessant use, composed of 54 inductionless coils of insulated copper wire, each giving 33 ohms resistance, and having a condenser of 1 microfarad capacity at the juncture of each pair of coils, and one at the termination of the series. This represented a circuit of a total capacity (K) of 54 microfarads, and of a total resistance (R) of 1,782 ohms, the K R being 96,228. This was equivalent to an ordinary submarine cable of 162 nauts length. It was not sufficient for our growing wants; and another similar set was recently made, but it did not give the same results. The resistances were exactly the same, but the individual capacities differed. This difference of about 5 per cent. was, of itself, of no practical consequence for the particular purpose for which the cable was constructed; but on carefully comparing the two "cables" with telephones it was found that with the same nominal K R the one gave 30 per cent. better results than the other. This was a surprising and unexpected result. I thought it might be due to inductance, but none, neither *self* or *mutual*, could be detected.

The insulation, taken after one minute's electrification, of each was:—Old cable, 172·8 megohms per naut; new cable, 82·8 megohms per naut, so that the difference was in favour of the old one. But the electrification of the new one was much less than that of the old one. The difference in the reading between the first and second minutes on the former was $\frac{1}{20}$th of that of the latter.

Each cable was then rapidly charged and discharged 1,200 times, at varying rates, with an E.M.F. of 40 volts, and the cumulative remaining charge in each case read by deflection on

* Abstract of a Paper read before the British Association in Section A, Edinburgh, August, 1892.

* Paper read before the British Association in Section A, Edinburgh, 1892. Lord Kelvin proposes to call this useful instrument a "Leyden," because the term "condenser" is applied to other more appropriate mechanical and physical apparatus.

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a Thomson galvanometer. This was done by passing a 10ft. length of perforated slip through a Wheatstone's automatic transmitter. The following are the results :—

Number of discharges per second.	Discharge.		Percentage difference.
	New.	Old.	
20	46	28	39
40	86	55	36
80	151	100	33
120	200	136	32
160	237	168	29

This clearly shows that the effect is due to absorption. Electrification, polarisation, and absorption, are phases of electrolytic work done by the current upon the dielectric. The material itself, or the impurities contained in it, being slightly decomposed by the leakage current, a counter E.M.F. is set up, which increases the apparent resistance (electrification), it gives a current of discharge reverse to that of charge (polarisation); it absorbs a quantity of electricity, the undissipated part of which is recovered as a discharge current. The condenser acts, in fact, like a secondary cell.

We are now using better paper than formerly—that made from the best linen rags, thinner tinfoil, and better wax, the best refined unadulterated white paraffin, having a melting point of from 125°F. to 128°F. Resin was formerly mixed with the wax, and when hot and liquid it was painted on the paper with a brush. The paper is now thoroughly dried and well saturated with wax by soaking under pressure, so as to get rid of all the moisture. Hence there is less electrification and less absorption, and hence the difference." In the old type of condenser we observed a variation of capacity due to temperature, but in the new type this has disappeared. This effect of absorption on the effective capacity of the condensers and of insulated conductors is new to me; and as it may be new to many others, I have thought it to be of sufficient interest to bring it before Section A.

It is a new term to be added to the equation of energy of compound circuits, and it has evidently a material influence upon the retardation of signals in long submarine cables. It has an equally important influence on the efficiency of telephone circuits, and it accounts partially for the great difference in my K R law between the observed effects of aerial and those of subterranean or submarine conductors. The former are always much superior to the latter. This would be due to the absence of polarisation in air, as well as to other electromagnetic and electrostatic causes. No work would be done on the molecules of air, no energy would, therefore, be absorbed, and no retardation of currents from this cause would ensue. An air dielectric is clearly the "Holy Grail" of the electrician.

ON THE EARTH-CURRENT STORMS OF 1892.*

BY W. H. PREECE, F.R.S.

The year 1892 has been remarkable in the number and severity of those electric storms which interfere so seriously with telegraphic communication. Unfortunately, observations made upon them on working circuits are rarely reliable. Their arrival and departure are sudden, they come when they are least expected, and they occur in busy hours, when the wires are fully occupied with more remunerative currents, and when the staff is fully engaged. Their presence, duration, and relative intensity are so exactly coincident with magnetic disturbances that the recorded observations in magnetic observatories of needle variations may be taken to indicate the same elements of earth currents also, but they do not give their direction nor their absolute intensity. Their general direction is determined by the simultaneous observation of many circuits running in many directions, and noting the lines of maximum and those of no disturbance. This gives the position of the equipotential planes on the surface of the earth, and the intensity of the currents gives the difference of potential between these planes.

I have not succeeded in obtaining definite facts to prove that these planes are perpendicular to the line joining the centre of the earth and the centre of the sun; but there is little doubt that it is so, for telegraph circuits running in this direction experience the maximum disturbances, while those running at right angles on the equipotential planes suffer no disturbance. Those that experience the maximum disturbance in the forenoon are not affected in the evening, and *vice versâ*.

The storms commenced on January 4th, and they have been observed at frequent intervals since. The great storms occurred on February 13th, March 12th, April 24th and 27th, May 18th, and July 16th. The intensity of the maximum currents observed frequently exceeded 0·045 ampere, or 45 milliamperes, which much exceeds in strength the working currents. Hence ordinary telegraph working was paralysed, and we had to resort to metallic circuits and to the use of condensers to maintain telegraphic communication. The effect of such currents on our railways might be positively dangerous, for they ring bells and reverse the block signals. A current of 0·045 ampere on an ordinary iron telegraph wire (No. 8), means 0·54 volt per mile, so that the equipotential planes differing by 1 volt would have been placed about two miles apart. These earth currents, though variable, are always continuous, and give no indication of alternations. The simultaneous appearance of Auroræ shows that disturbances on the sun's photosphere, as indicated by sun-spots, produce electrostatic and electromagnetic effects on the earth's surface of enormous magnitude.

The appearance of earth currents is invariably simultaneous over the whole globe. Observers abroad would benefit science if they would record the maximum strength, in milliamperes, of the currents received, the geographical direction of the terminal earths of the circuits affected and unaffected, the resistance, in ohms, of the circuits on which the currents are measured, and if they were to give the times of observation in Greenwich, and not in local time.

* Paper read before the British Association in Section A, Edinburgh, August, 1892.

THE DESTRUCTION OF LIGHTNING PROTECTORS BY RECENT MUNICIPAL LEGISLATION.*

BY W. H. PREECE, F.R.S.

The immunity of private houses from being struck by lightning is very marked, and this is considered to be due to the fact that the lead on our roofs and the iron stack pipes that drain these roofs, connected as they are together, form admirable lightning protectors. Any charge of atmospheric electricity which may fall upon a house so protected is conveyed harmlessly away to the earth. Householders are now required to remove these pipes from direct connection with the drains, and to leave an air space between the end of the pipe and the grating of the drain. The result is that the electric conduction of the pipe is broken, the stack pipe ceases to be a lightning protector, and houses are left exposed to the dangers of atmospheric electricity.

The remedy is very simple. The pipe need not be entirely cut away; three-fourths of its circular section may be removed for the distance required and one-fourth may be left to maintain the old electrical connection, or if the separation has been effected, then the stack pipe should be connected with the drain by a wire or rod so as to restore a path for the charge to the earth.

Householders are also now compelled to put up stack pipes to ventilate their soil pipes, erecting above their roofs a metal tube forming a prominent object, exposed to the atmospheric charge and terminating frequently in an earthenware pipe on the first floor. They are thus liable to be struck by lightning without offering any means of escape. They should be connected electrically with the earth, either directly or indirectly, through the stack pipes, which would then make them sources of safety rather than of danger.

* Paper read before the British Association in Section G, Edinburgh, August, 1892.

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EXPERIMENTS ON ELECTRICAL RESISTANCE.*

BY DAWSON TURNER, M.D.

M. E. Branly has reported in the *Bulletin de la Société Internationale des Electriciens*, May 9th,† some experiments on the influence of currents of high potential upon electrical resistance. Some of these experiments have been repeated by the author. It is well known that metallic powders present a very great resistance. This can be lowered to an extraordinary degree by the passage of a spark in the neighbourhood. The author has tried amongst other substances, powdered aluminium, finely divided copper, annealed silenium, iron filings, small shot, mixtures of aluminium and resin fused into a solid stick, &c. The best results were obtained with the first two. A short glass tube is filled with powdered aluminium, and placed by means of copper wires passing through corks, in circuit with one or two cells and a galvanometer. The needle of the galvanometer will remain at zero. The resistance of the aluminium is very great. If a spark from an induction coil be passed in the vicinity, the resistance will become at once diminished, and the galvanometer needle will be deflected. Thus, though there was at first no appreciable current, there may now be one of 250 milliamperes. The powder will, if undisturbed, remain a conductor for some little time, but if the table be shaken or the glass tube be moved, the initial resistance at once returns and the needle passes back to zero. After the resistance has been once lowered in this way, the powder gets into a much more sensitive condition; a spark at a great distance lowers the resistance and the slightest jar restores it. The author was not successful with ordinary iron filings, perhaps because they were not sufficiently finely divided. More shaking does not restore the resistance of the solid stick of aluminium and resin, but the application of a little warmth does. These experiments would appear to suggest that the molecules become arranged in a definite order under the influence of a discharge, even though the latter occur at a considerable distance.

THE TEMPERATURE VARIATION OF THE MAGNETIC PERMEABILITY OF MAGNETITE.

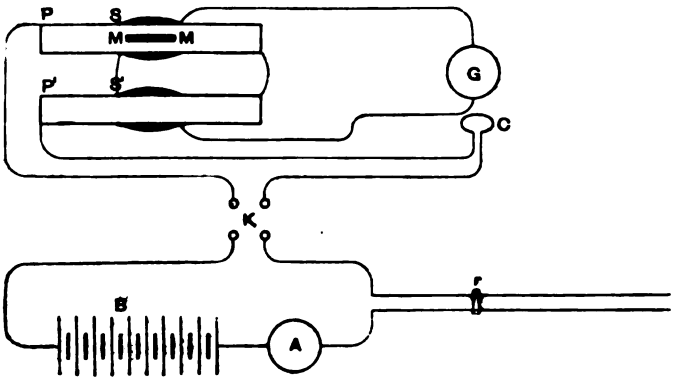
BY EDWIN H. BARTON, B.SC., AND W. WILLIAMS, B.SC.

After being engaged for some time upon the Magnetic Survey of the United Kingdom, Prof. Rücker put forward his Theory of Terrestrial Magnetism (*Proc.* Roy. Soc., Vol. XLVIII., June 19, 1890), "Relation between Magnetic Permeability of Rocks and Regional Disturbances." In connection with this theory it was desirable to ascertain the permeabilities of various rocks both at ordinary and high temperatures. The investigation referred to in the present preliminary Note is an instalment in this direction.

Prof. Rücker proposed this undertaking, and indicated the plan to be followed. It was then carried out under his supervision at the Royal College of Science, London (as follows:—W. Williams worked out the theory of the method, calculated what coils would be suitable, and wound them accordingly. E. H. Barton arranged the apparatus, eliminated disturbances, took the observations, and plotted the results.)

For measuring the susceptibility of the magnetite the ballistic method was adopted. Since the specimen was to be exposed to high temperatures, the coil to receive it was insulated with asbestos paper and wound upon a porcelain tube. The secondary coil was further insulated from the primary by two sheets of mica, to obviate the probability of leakage between the two. The temperature of the magnetite, when heated, was estimated from the consequent E.M.F. of a thermo-electric couple of platinum and osmium-iridium. One of the junctions was round the specimen of magnetite, and the other in a beaker of water. This couple was first calibrated by placing one junction in melting ice, boiling water, and sulphur vapour* respectively, the other junction being meanwhile at ordinary temperature. The arrangement adopted for obtaining the sulphur vapour and the temperature assigned to it were those published by Messrs. Callander and Griffiths in the *Proc.* Roy. Soc.*

The electrical connections used for measuring the induction effects are diagrammatically represented below (Fig. 1):—



M M, Specimen of magnetite. P and S, Primary and secondary coils which are heated (by gas stove not shown). P' and S', Compensating coils. B, Battery. A, Ammeter. r, Adjustable resistance. K, A "Pope's" commutator. C, Compensating coil. G, Highly sensitive low-resistance galvanometer.

FIG. 1.—Diagram of Electrical Connections for measuring the Induction Effects.

Eight distinct disturbances were dealt with. Some of them were eliminated; others measured, and the necessary correction applied when deducing the true effect due to induction.

The result obtained may be exhibited by a curve whose abscissæ are the temperature of the magnetite, and whose ordinates are proportional to the induction effects due to its presence, the impressed magnetic field being constant. Commencing at ordinary temperature, it is seen from the curve (Fig. 2) that the susceptibility for the specimen used rose

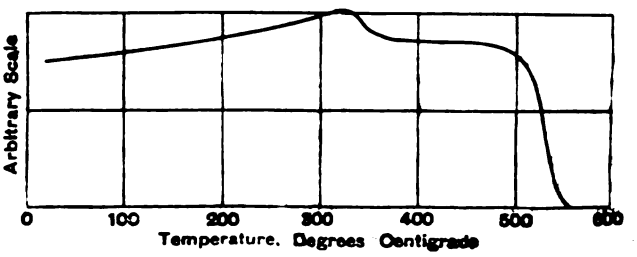


FIG. 2.—Curve showing the Variation of the Magnetic Susceptibility of Magnetite with Temperature, the impressed magnetic field being constant.

gradually at first with increase of temperature, reached a maximum at 325°C., then fell away to zero at 557°C. The sharp peak in the curve at 325°C., though apparently anomalous, was confirmed by careful repetition of the measurements in that region. It cannot be, therefore, regarded as due to experimental errors.

The *impressed* magnetic field (treating the primary solenoids as infinitely long) was 4·8 C.-G.-S. units. The actual field within the specimen of magnetite (when cold) was of the order 3·4 C.-G.-S. units. The determination of the absolute values of the permeability for the various temperatures is not yet completed. When this has been done we hope to publish (probably in the *Proc.* Roy. Soc.) a fuller account of the methods and result of the investigation.

The Telephone in France.—The balance-sheet of the French telephones for 1891 shows gross receipts amounting to £223,000, the length of line at the end of that year being nearly 1,200 miles, and the number of subscribers 18,191, to which total Paris contributes no less than 9,965.

* Paper read before the British Association in Section A, Edinburgh, August, 1892.

† See also *The Electrician*, Vol. XXVII., pp. 221 and 448.

* "On a Determination of the Boiling Point of Sulphur, and a Method of Standardising Platinum Resistance Thermometers by reference to it" (*Proc.* Roy. Soc., Vol. XLIX., No. 296, p. 56, December 18, 1890).

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THE UNITS DISCUSSION AT THE BRITISH ASSOCIATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to my opening remarks at the above discussion, as published in proof in your issue of August 5th, p. 371, I wish to say that, after conversation and correspondence, I did not bring forward all the suggestions there set down, but withdrew Nos. 4, 5, 6, and 8. That is to say, I abandon the idea of altering either the watt or the coulomb, although they are rather small for practical purposes. I am further disposed to amend No. 12 by recommending for the "gauss" $0{\cdot}4\,\pi$ ampere turns, instead of one ampere turn.

The resolutions that I wish to press are Nos. 1, 9, 10, 11, 14. It is influentially felt that the nomenclature of magnetic units had better be deferred for a time; but, meanwhile, teaching is much more difficult than it would be with a couple of judiciously chosen names for quantities in the magnetic circuit.

There is a slip in the proof you printed, which I will ask you to correct, viz., in the ninth paragraph, under head "total induction," I say there that the pull between two parallel surfaces [one square centimetre in area] joined by a weber is so much. The words in square brackets were omitted by me, thus making an error. The pull depends not only on the total lines, but on their concentration; a weber distributed over a square metre of area would give a pull of only 40 tons.

I have received letters from Dr. Fleming, Prof. A. Gray, and Mr. James Swinburne, and these I send as valuable contributions to the discussion, if you obtain the authors' consent to their appearance.—Yours, &c.,

OLIVER J. LODGE.

With many of Dr. Lodge's suggestions I entirely agree, especially in the desire to give simple names to the practically used units. First, amongst the practical units not already named, but for which a name should be fixed, is the practical unit of magnetic induction. As a short practical name for a total induction of 10^8 magnetic "lines," I have generally used the term "gauss;" and in a Note in *The Electrician* for 1890, Vol. XXV., p. 445, suggested the word "Gilb" or "Gilbert" for the same as an alternative. Whether we adopt "Gauss," "Gilbert," or "Weber" as the name of this unit of total induction there are many good reasons for taking the practical unit as equal to 10^8 C.-G.-S. units, although most inductions which occur in practice would only be fractions of this practical unit in magnitude. With respect to the unit of magneto-motive force it hardly seems necessary to christen the ampere-turn. On the other hand, *80 ampere-turns* is very nearly = 100 C.-G.-S. units of magneto-motive force, and might very conveniently be named.

There ought to be a simple relation between the so-chosen units of total induction and magneto-motive force when considered with reference to a non-ferric circuit. As the term "gauss" has been used for a unit of total induction, I should prefer to see it kept to denote 10^8 "lines of force," and the term "weber" applied to the unit of magneto-motive force, whether 80 ampere turns or to 0·8 ampere-turn $= \frac{10}{4\pi}$ ampere-turn.

With respect to other proposed changes, the suggestion to call a micro-farad a farad will probably meet with acceptance; but it is questionable whether the proposal to make the "watt" a unit of energy instead of power will be so favourably received. The watt is a convenient unit for measuring the power given to an incandescence lamp or taken up in a transformer, and the power sent out from an electric station is equally well measured in kilowatts or megawatts. The Board of Trade unit of energy, which has not yet been successfully named, might quite well be left as it is at present, and simply called "a unit." The non-electrical public would not understand its meaning a bit better by giving it a name, and the electrician thinks of it as a kilowatt-hour analogously to ampere-hour. I hope it may be possible to arrive at a decision on the subject of a practical name for the unit of inductance or coefficient of self-induction. There seems much to be said in favour of adopting the term "Henry," and it has, in fact, been widely used for the name of that unit, which is variously called a secohm or a quadrant.

Substantially, then, I agree with Dr. Lodge's proposals, only I would prefer to see the "gauss" taken as the unit of total induction and the "weber" as the unit of magnetic potential, and made equal to 80 ampere-turns, or to $\frac{1000}{4\pi}$ ampere turns, to facilitate calculations. This will make the unit of magnetic potential equal to the difference of magnetic potential between two points ten centimetres apart in a uniform magnetic field, whose strength is 10 C.-G.-S. units. I deprecate, however, the change of the "watt" into a unit of energy; the "watt" and "kilowatt" should remain units of power.

J. A. FLEMING.

I agree with Dr. Lodge on the whole, and should like to see some of the reforms he advocates introduced. There are a few points, however, on which I rather differ from him; but perhaps we do not differ very much, after all. It is not, I think, a matter of no moment what we call a unit, and names of eminent electricians, if used for this purpose, should not be mutilated or distorted more than can be helped. I dislike, for example, the word *mho* or *mo* on this account very much. It is a *perversion* which I am sorry Lord Kelvin gave his authority to. It is also much to be regretted that Mr. Oliver Heaviside, who has done so much for the improvement of electrical nomenclature, should talk of such things as *Macs*! *Mac* has nothing to do with the name Maxwell whatever, and even if it had it would be quite as great a barbarism as *Am*, which has come into use. Life is surely not so short that we have to contract mere great names into what are dangerously like grotesque and familiar nicknames, which one hardly cares to associate with the great men whose memory it is designed to perpetuate by association with electric and magnetic units. If it is, another reason has been added for thinking life not worth living. If we must have monosyllables, and cannot get them without cutting up or perverting names of illustrious electricians, let us endeavour to find if possible combinations of vowels and consonants, without any previous associations whatever.

A. GRAY.

[ABSTRACT.]

As electrical units are a subject in which I take interest, I will offer some remarks.

Although in dealing with the charge of station batteries the coulomb is useless, it is convenient in dealing with circuits with pilot coils and ballistic galvanometers. Hibbert's magnet standard of what Dr. Lodge would call turn-weberage, or micro-weberage turns, is conveniently given in ohm coulombs. Then, with a given galvanometer resistance, we know the time integral of the current at once. If the electrostatic units are to have names they should not be names of people, but should be in same system as dyne, erg, &c.

The farad is, of course, too large. It does not take long to say micro-farad, and people know what it means. They will not if a change is made.

The name watt is universally used and universally understood, and it is quite useless to change it. The watt is never used by engineers to denote energy. The Board of Trade call 3,600 joules a supply unit. This barbarous term will cause less trouble than calling it a watt.

A name is wanted for total induction. I always use either "total induction," or "field." What Dr. Lodge calls a weber 10^8 "lines" has been called a "gauss," and I think also a "thom" or "tom," and a "hop." As it is a practical unit it might have a man's name. It should be 10^8 lines, not $\cdot 4\,\pi\,10^8$, as that would be very inconvenient.

If we are going to have magnetic reluctance ideas we do not need self-induction. Self-induction is a purely academic notion. In practice one always has to deal with a back or forward E.M.F. The definition of self-induction as the field per ampere multiplied by the turns is fundamentally wrong for practical purposes, it should deal with $d\,\mathrm{F}/d\,c$ not C. All practical magnetic circuits have iron and variable coefficients of self-induction. Similarly the electrokinetic momentum can only come in as a rate of increase or decrease, and $d\,\mathrm{F}/d\,c$ and $-d\,\mathrm{F}/d\,c$ are seldom numerically equal. Self-induction is an absurd idea anyhow for practical work. $\mathrm{L} = \cdot 4\mathrm{T}^2\mathrm{K}$ where K is the conductivity or magnetic willingness or whatever Mr. Oliver Heaviside calls it. K varies with the excitation, of course. Generally the term "magnetic circuit" is meaningless, for it is not defined. In this equation, however, the K really includes the field through each turn. In fact $\mathrm{L} = \Sigma\, t\mathrm{K}$. It is the vagueness about the circuit that makes the magnetic resistance idea so little use. The magnetic resistance of a "tube" of magnetic field is something definite. The magnetic resistance of a dynamo circuit is indefinite on account of leakage cutting the exciting coils themselves.

Magneto-motive force is a wrong term. A force is the slope of a potential, not a potential. Maxwell mixes electric force $\frac{d\,v}{d\,l}$, or $\nabla\,\mathrm{V}$. I think he writes it independently of x y and z, and electromotive force V or $\mathrm{V}_1 - \mathrm{V}_2$. I always call the ampere turns "excitation;" there is no need to call it magneto-motive force. As to suppressing $4\,\pi$, it must come in somewhere else, so it may as well be left where it is.

Before making new units those in currency should be employed correctly. For instance, specific resistance should be in ohm-centimetres, not in ohms. Hospitalier uses this term, and I am the only Englishman, as far as I know, who follows him. I think I am alone, or nearly alone, in writing of megohm-miles, and not of megohms per mile. Again, most writers, even the most scientific, write of quantity of current or strength of current, when they mean current. It is as bad as "rate of speed." Again, "passing a current" is absurd. Passing electricity is correct, and the current is the rate at which it passes. Some day the system of nomenclature may be simplified by the popularisation of the idea of the curl. Anything which gives simple relationships avoids extra names. About two years ago a German writer brought out a treatise on dynamos, in which he regarded induction as a sort of spiral arrangement, a bundle of infinitesimal corkscrews of infinitesimal pitch. He had really got hold of the notion of curl relationship between the electric and magnetic circuit, and worked it out independently. Any simple relationship avoids useless names. Volt-ampere was really much better than watt, and volt-coulomb than joule.

The electric circuit is a particular case of a solenoidal distribution; the magnetic circuit is another, and there are some dozen more. Except that they are both particular but different cases, they have nothing in common. The magnetic circuit corresponds to the displacement circuit in electrostatics. B corresponds with electrostatic induction, electric with magnetic force, and so on. To compare B with current density is absurd, and can not help even the practical man. By all means let it be understood that there is such a thing as a magnetic circuit, but not that it is analogous in particular to the electric circuit. At Cardiff I mentioned that L was no

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use in practice, and that no one at my works knew what the coefficient of induction of a transformer was, and I was told that this was a disgraceful state of ignorance.

I do not know if I am in order in suggesting that standard cells should not have a so-called saturated solution of $ZnSO_4$. It is not definite. A "normal" solution would be definite, and is easily made up. It gives a lower temperature coefficient, and if real mercurous sulphate is used instead of a mixture of sulphates it would be found that they were more accurate than standard resistances. Even if saturated cells agree it does not follow they are right, as their temperature coefficients vary together.

JAMES SWINBURNE.

THE VARLEY TESTIMONIAL.

The following letter has been extensively circulated amongst the members of the electrical profession :—

For a considerable time past there has existed a feeling amongst some of the older members of the electrical profession that the life-long labours in electrical research of Mr. S. A. Varley should be recognised by some substantial testimonial befitting his reputation as a scientific investigator. It was suggested some time ago by several technical journals that the electrical trades would be doing a gracious and just action by presenting Mr. Varley with some substantial token of their indebtedness ; but the suggestion did not assume any practical shape until recently, when the following gentlemen manifested their willingness to co-operate, and expressed their hearty sympathy with the object in view :—Major Flood Page, Mr. Augustus Stroh, Mr. F. L. Rawson, Sir David Salomons, Mr. Thos. Parker, Dr. John Hopkinson, Mr. Alexander Siemens, Mr. D. de Castro, Prof. D. E. Hughes, Mr. W. A. Gorman, Mr. J. W. Swan, and Mr. R. E. Crompton.

A meeting was held on Friday, June 17th, in the rooms of the Institution of Electrical Engineers, at which were present Messrs. R. E. Crompton, T. E. Gatehouse, W. A. Gorman, Prof. D. E. Hughes, T. Parker, Major Flood Page, A. Stroh, and J. W. Swan, when a resolution to the following effect was passed and sent to the technical press for publication :—"That this meeting was unanimously of opinion that Mr. Varley deserved substantial recognition, and that everyone interested in electrical engineering should be invited to join the committee for the purpose of discussing the best form that this recognition should take, and that a draft circular should be prepared ready for submission to a meeting of a committee, which should be invited to attend at the rooms of the Institution of Electrical Engineers, at 28, Victoria-street, S.W., on Friday, July 1st, at 4 o'clock."

This meeting was accordingly held, and a considerable number of gentlemen were present, including Lord Kelvin, Major Flood Page, Mr. A. Siemens, Profs. D. E. Hughes, John Perry, Silvanus P. Thompson, and George Forbes, Messrs. T. E. Gatehouse, R. E. Crompton, A. Stroh, W. Gorman, and others. Lord Kelvin took the chair. A number of letters were read from gentlemen who were unable to attend, but who had signified their hearty assent with the objects of the meeting. Among these were Sir F. Bramwell, Sir H. Mance, Sir Leppoc Cappel, Sir D. Galton, Sir J. Pender, Dr. Gladstone, Mr. W. H. Preece, Profs. Ayrton, Kennedy, Lodge, and Fitzgerald, Messrs. J. W. Swan, Belshaw, J. E. H. Gordon, Manville, Massey, R. K. Gray, Jackson, and Goolden. Mr. T. E. Gatehouse then gave a very interesting account of Mr. Varley's life, and the services that he had rendered to electrical engineering. After some remarks by Mr. Crompton, Major Flood Page, Mr. Siemens, and Profs. Thompson and Perry, the following resolution was put and carried :—"That this meeting approves of a testimonial being got up on behalf of Mr. S. Varley; that the whole of these gentlemen who have given their names as willing to serve on the committee be, and are hereby appointed a committee to act in the question of the Varley Testimonial, and that an executive committee be hereby appointed, consisting of Lord Kelvin, Prof. S. P. Thompson, Prof. Perry, Mr. A. Siemens, and the gentlemen who attended the preliminary meeting." Among other matters it was suggested that the aid of the Institution of Electrical Engineers be sought to ask that the Government should grant a pension to Mr. S. A. Varley; and that the general committee should consist of the gentlemen who had attended the preliminary meeting, those who had attended that day, and all the gentlemen who had written expressing their sympathy with the objects of the meeting, and that every effort should be made to extend the list. Further, that a statement setting forth what Mr. Varley has done should be prepared by Messrs. A. Siemens, T. E. Gatehouse, Silvanus P. Thompson, and R. E. Crompton, and that this statement, which follows, should be circulated as widely as possible among members of the electrical profession at home and abroad. A brief sketch of Mr. Varley's career will serve to show what signal services he has rendered to the cause of electrical science and the honour his discoveries have conferred upon this country.

Mr. Samuel Alfred Varley was born in London in 1832, and was the third son of the late Mr. Cornelius Varley, an active scientist and artist, and one of the founders of the old Water Colour Society, now the Royal Institute. At the age of 14 Mr. Varley commenced to study chemistry, and attended every scientific lecture he could obtain access to. In 1849, in conjunction with his elder brothers, he made numerous experiments, constructing with his own hands some hundreds of battery cells, but the troublesome manipulation attendant on their use caused him to turn his attention to magnetism. In 1852 Mr. Varley entered the service of the Electric Telegraph Company, and assisted in some experiments on the retardation of electric signals through underground and submarine circuits, which led to the development of his elder brother's (C. F. Varley) double-current system. In 1854 Mr. Varley was appointed to the charge of the telegraphs of the Liverpool district. About this period he constructed an electric chronograph, to measure the small intervals of time occupied by the passage of the electric signal to time balls and the time lost in the discharging apparatus. In the spring of 1855 Mr. Varley was appointed to the charge of the first field telegraphs used in war, and proceeded to the Crimea. After the fall of Sebastopol he took charge of the submarine telegraph connecting Constantinople and Varna. In 1858, when the Atlantic Cable was being constructed, he wrote a Paper, read before the Institution of Civil Engineers, "On the Electrical Qualifications requisite in Long Submarine Cables," and was shortly afterwards elected an associate member of that Institution. In the Paper referred to above, Mr. Varley opposed the views of the electrical advisers of the Company. Faraday, who had publicly supported their opinions, endorsed Mr. Varley's ideas immediately after receiving a copy of his Paper. Mr. Varley followed this up by reading a second one before the Society of Arts in 1859, "On the Practical Bearing of the Theory of Electricity to long Submarine Telegraphy." In this Paper he suggested, among other things, the use of artificial lines, which have since proved of such value in connection with duplex working. In 1866 Mr. Varley discovered for himself the reaction or self-exciting principle, and at that early date constructed his first machine of the pure dynamo type which is now in the Museum at South Kensington. His dynamo of 1866 was exhibited at the Inventions Exhibition of 1885, and for this he was awarded a gold medal. The controversy which subsequently arose on this invention may be held to have been fitly summed up by the late Robert Sabine, C.E. (son-in-law of Sir Chas. Wheatstone), in the following words :—"Prof. Wheatstone says he was the first to complete and try the reaction machine. Mr. S. A. Varley was the first to put the machine officially on record in a provisional specification, dated December 24, 1866, which was, therefore, not published until July, 1867. Dr. Werner Siemens was the first to call public attention to the machine in a Paper read before the Berlin Academy on January 17, 1867." (See *Engineering*, November, 1877.) In 1866 he introduced needle-telegraph coils, in which soft iron magnetically-induced needles were substituted for tempered steel needles. These induced and consequently undemagnetisable needles entirely superseded the old form introduced by Wheatstone and Cooke, and were largely adopted by the Postal Department. In the same year (1866) he designed a system of electric train inter-communication. In the year 1875 Mr. Varley became assistant-manager of the works of the late British Telegraph Manufactory (Limited); and as the first Gramme machines constructed in England were manufactured by this firm, he had ample opportunities of studying the characteristics of both series-wound machines and those having a separate armature for excitation of the field magnets. There is scarcely a doubt that Mr. Varley's investigations at this period led to the invention of compound winding; for in 1876 he patented a series-shunt or compound-wound dynamo, and, in three legal suits, the claim that this specification first described a system of compound winding has been fully sustained. Mr. Varley has from time to time contributed Papers read at the meetings of the British Association, among which may be mentioned one "On the Mode of Action of Lightning on Telegraph Circuits," wherein he described a lightning bridge designed by himself, a number of which are now doing duty, although fitted up more than 20 years ago.

But Mr. Varley's *magnum opus* is the important part which he took in the invention and perfecting of the dynamo, perhaps the most striking invention of the century, and upon this his fame as a patient, conscientious, and earnest scientific investigator of the Faraday school will permanently rest. His researches were undertaken in the true spirit of science, and no thought of self-emolument has ever caused him to deviate from the path which he has pursued throughout an eventful, although eminently simple and blameless life, a life in which self-denial and self-sacrifice have had no small share. Like many men of genius he was far ahead of the times, and has lived to see others reap the benefit of his great discoveries. His nervous and retiring disposition has for years kept him from the busy haunts of men, and to the younger generation of electricians he exists only in name—a name, however, that will live as long as the dynamo is employed in the service of man.

The Committee consists of Lord Kelvin, Sir Leppoc Cappel, Sir Frederick Bramwell, Sir Henry Mance, Sir John Pender, Sir Douglas Galton, Sir David Salomons, Prof. Ayrton, T. O. Belshaw, G. Binswanger, R. E. Crompton (Hon. Sec.), D. de Castro, D. Fitzgerald, Prof. George Forbes, T. E. Gatehouse, Dr. Gladstone, W. T. Goolden, J. E. H. Gordon, W. A. Gorman, R. K. Grey, Prof. D. E. Hughes, Dr. John Hopkinson, R. C. Jackson, Prof. Kennedy, Prof. Oliver Lodge, E. Manville, W. H. Massey, H. Mavor, Major S. Flood Page, T. E. Parker, Prof. Perry, W. H. Preece, F. L. Rawson, A. Siemens, A. Slatter, A. Stroh (Hon. Treasurer), J. W. Swan, Prof. S. P. Thompson. Subscriptions may be sent to the Hon. Treasurer, at 98, Haverstock-hill, N.W.

British Association Money Grants.—At the meeting of the General Committee of the British Association last Wednesday week the following were among the grants made for scientific purposes :—Prof. Carey Foster, electrical standards, £25, and Mr. H. Fox, magnetic work at the Falmouth Observatory, £25. The total sum granted was £1,000. The committee subsequently adjourned to meet again at Nottingham on September 13, 1893.

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THE BOARD OF TRADE AND ELECTRICITY METERS.

The following letter to the London County Council relating to the approval of electricity meters by the Board of Trade, has been sent us for publication :—

(Copy.)

Board of Trade (Railway Department),
London, S.W., August 15, 1892.

Electric Lighting Acts, 1882 and 1888.

Sir: With reference to previous correspondence on the subject of the approval by this Department of the pattern and construction of electricity meters for the purposes of Electric Lighting Orders, I am directed by the Board of Trade to inform you that, having carefully considered the several patterns of meters which have been submitted for their approval, they are of opinion that it is desirable that they should have further experience of the practical working of the meters in actual use before any formal approval is given. Though some of the patterns of meters which have been submitted have many merits, and the laboratory tests which have been applied have been, in several particulars, satisfactory, no meter has shown such perfection in principle, design, and construction, as to justify the Board of Trade in the conclusion that serious defects might not appear in actual working. Under these circumstances the Board of Trade are of opinion that further experience of the behaviour of meters should be gained, and possibly further inquiry made, before the final decision of the department is arrived at. Representations, moreover, have been made to them with regard to the effect on the interests both of those who are engaged in supplying electrical energy and of those whose efforts are being continuously directed to the invention of meters which would be produced were any approval, even of a temporary and provisional kind, to be given now to any particular pattern or patterns of meter.

With the view of acquiring as fully and as thoroughly as possible information as to the behaviour of meters under working conditions, the Board of Trade would be glad of the co-operation of the London County Council in providing for a thorough practical test ; and they would suggest that the Council should, at their early convenience, instruct their representative to confer with Major Cardew, the electrical adviser of the Department.

Pending the acquisition of this information, which they anticipate will occupy a period of about twelve months, the Board of Trade are not prepared either to approve the pattern and construction of any electricity meter not yet approved, or to further extend the approval already given in the case of the Shallenberger meter, which has been approved for the purposes of the following Act and Orders only, namely :—The Metropolitan Electric Lighting Act, 1889 ; the Metropolitan Electric Supply Company (West London) Lighting Order, 1889 ; the Metropolitan Electric Supply Company (Mid-London) Lighting Order, 1889 ; the Metropolitan Electric Supply Company (Paddington) Lighting Order, 1890 ; the House to House Electric Light Supply Order, 1889.—I am, &c.,

(Signed) Courtenay Boyle.

The Clerk to the London County Council,
Spring Gardens, S.W.

SOURCES OF HEAT GENERATED IN THE GALVANIC BATTERY.*

BY MAGNUS MACLEAN, M.A., F.R.S.E.

These experiments were suggested by a Paper read by Lord Kelvin to the British Association in Belfast in 1852, and reprinted in "Mathematical and Physical Papers," Art. LV. In that article it is stated "that a feeble continued current, passing out of an electrolytic cell by a zinc electrode, must generate exactly as much more heat at the zinc surface than the same amount of current would develop in passing out of an electrolytic cell by a platinum electrode, as a zinc platinum pair working against great external resistance would develop in the resistance wire by the same amount of current."

In the first set of experiments two equal and similar glass vessels were used, with about 500 c.c. of dilute sulphuric acid in each. The pairs of elements were Zn Zn, Zn Pt. The rise of temperature due to currents of from 4 to 14 milliamperes, obtained from the Smee cell, was observed at intervals of a few minutes for about four hours. There are many sources of error in this mode of experimenting, besides the difficulty of observing the small rise of temperature ; but generally the rise of temperature of the Zn Zn cell was greater than that in the Smee cell. In some of the experiments the Smee cell showed a higher rise of temperature ; but this latter result is no doubt due to local causes, such as polarisation, &c.

In the second set of experiments a current of 39 milliamperes was obtained from the Smee cell, and in every case the rise of temperature of the Zn Zn cell was greater than the rise of temperature of the Smee cell ; and the average rise corroborates the statement of Lord Kelvin quoted above.

Thus average rise of temperature of Zn Zn cell above Smee cell is 0·2° C., and hence heat generated = 500 × ·85 × 0·2 = 85. Equating this to the work done by Smee cell in four hours, we get

$$E = \frac{85 \times 42 \times 10^7}{\cdot 0039 \times 4 \times 3{,}600} = \cdot 64 \times 10^8 = \cdot 64 \text{ volt.}$$

In the third set of experiments the two elements in each cell were separated by a piece of blotting-paper, and four thermometers used to indicate the rise of temperature at each electrode. It was found that the rise of temperature at the zinc anode plate was greater than at the zinc cathode.

In another series of experiments with four cells containing dilute sulphuric acid, in which the pairs of elements were Zn Zn, Pt Pt, Pt Zn, and Zn Pt, currents from an external source of half, one, and two amperes were allowed to flow for about an hour, and the rise of temperature in each cell recorded. Tables of results are given showing that the rise of temperature in the cell in which the current flowed from platinum to zinc is in every case higher than the rise of temperature in the cell in which the current flows from zinc to platinum. Taking the average of a number of experiments fairly agreeing among themselves, it is found that the mean rise of temperature in the four cells is :—

Time experiments lasted.	Current in amperes.	Zn Zn.	Pt Pt.	Pt Zn.	Zn Pt.
1 hour	½	0·45	0·6	0·53	1·07
40 minutes	1	0·45	0·75	0·6	1·37
1 hour	2	2·8	3·98	2·53	4·98

Direction of current <———

Mr. George E. Allan, Thomson Scholar in the Physical Laboratory of the University of Glasgow, carried out the larger number of the later experiments.

SOME EXPERIMENTS WITH A RUHMKORFF COIL.*

BY MAGNUS MACLEAN, M.A., F.R.S.E., AND ALEX. GALT, B.SC., F.R.S.E.

The quantity of electricity induced in a secondary circuit by a *make* in a primary circuit is equal to the quantity of electricity induced in the same secondary by a *break* in the primary. This fact was first experimentally proved by Faraday, and subsequent experiments and theory corroborate the statement. If, however, there is a non-metallic gap in the circuit, whether of air at ordinary pressure, or at much reduced pressure, as in vacuum tubes, the *break* impulse causes a flow in one direction, and the *make* causes either no flow or a much less flow in the opposite direction ; because the short intense impulse of the former breaks down the resistance, while the comparatively long and less intense impulse of the make either does not break down the resistance at all, or only does so to a much less degree, so that the effective resistance is much greater in one direction than in the other. To obtain the average difference of quantity of electricity set in motion in one direction above that in the other, a copper electrolytic cell was put in circuit with a vacuum tube and the secondary coil of a small Ruhmkorff coil. The solution in the cell was sulphate of copper of density 1·17 with one-half per cent. of commercial sulphuric acid added. The electrodes were No. 36 B.W.G. copper wire 0·012 centimetre diameter, and they were immersed in the solution as little as possible, so as to get the best current density for the deposit. The mean of seven experiments lasting from two to four hours gives the average electrolytic current, calculated from the gain of the cathode electrode, as one sixth of a milliampere. The gain of the cathode electrode was, in six of the seven experiments, greater than the loss of the anode electrode. An electrolytic cell was also put into the primary, and the mean ratio, in three experiments, between the gain of the cathode in the primary and the gain of the cathode in the secondary was 6,000. The mean current in the secondary was still about one-sixth of a milliampere.

One or two experiments were also tried without a vacuum tube in the secondary circuit, simply the electrolytic cell. Both electrodes showed loss. Again, a long thermometer tube full of sulphate of copper solution was substituted for the vacuum tube. The resistance of this tube would be comparable to that of the vacuum tube. (A Thomson multicellular was put at the terminals of the vacuum tube, which showed 165 volts. This would give the effective resistance of the vacuum tube to disruptive discharges as $165 \div \frac{1}{6000}$ = one megohm.)

The few experiments done with this thermometer tube in the circuit are inconclusive, as sometimes both electrodes showed loss,

* Paper read before the British Association, in Section A, Edinburgh, August, 1892.

* Paper read before the British Association in Section A, Edinburgh, August, 1892.

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and in an experiment lasting hours neither electrodes showed either gain or loss. These last experiments are to be continued with slight modifications. It is also intended to attach a tube to an exhaust pump, and try these electrolytic experiments at different pressures, from atmospheric pressure down to very low pressures or very high vacuums.

THE HUMAN BODY AS A CONDUCTOR OF ELECTRICITY.*

BY H. NEWMAN LAWRENCE, M.I.E.E.

That the human body is no ordinary conductor has been long acknowledged, but the peculiarity of its conductivity and the conditions under which this conductivity varies are subjects which have hardly yet been satisfactorily investigated. Much has been done to determine the true resistance of the living body, and a near approach to the solution of the problem has been arrived at, but the difficulty of the relative value of the resistance of skin and the internal portions of the body still remains. This difficulty is all the greater because, as has been shown by Erb, the skin on different parts of the body differs in its conducting power even after contact area and surface soakage have done all that is possible for them in the way of equalising matters. A knowledge of the distribution of conductivity, and how each particular section acts to the passage of current after the initial resistance has been overcome, is of scarcely less importance in connection with accidental contacts than that of initial resistance itself.

In a former communication which the author made to the Association (in conjunction with Dr. Harries) he dealt at some length with the resistance of the body to different forms of current. Since then he has made other observations, and though these are still incomplete, he has embodied some of them in this Paper in the hope that friendly criticism may help to a satisfactory solution of the problem at no distant date.

The author has endeavoured to separate from the total resistance of the body that portion which belongs to the skin alone. Carpenter, Stone, Stein, and quite recently Hedley, have adopted various methods to arrive at the same end, but their results can hardly be considered conclusive. By the use of internal as well as external electrodes he is led to conclude that the resistance of the skin of the cheek, or of similar skin, when circular non-polarisable electrodes of 2in. diameter are used, is 934 ohms for one layer, or 1,868 ohms for the two layers, as in ordinary contacts. These figures are, however, by no means true for skin in all parts of the body, because the number of sweat and other glands differs in many parts, and the extent of their presence in a given area has much influence upon the resistance and consequent conductivity of that area.

A number of readings obtained by passing continuous current for five consecutive minutes through different parts of the body appear in tables accompanying the Paper, and serve mainly to show the great power a steady flow of current, even for a short time and at low electromotive force, has to increase the conductivity of nearly all parts of the body. Some of the results are plotted on squared paper for more easy comparison. They form an interesting study, and, though manifestly incomplete, throw some light upon the distribution of conductivity throughout the limbs and trunk. That these figures would be very different when currents at the comparatively high electromotive force of light and power circuits were passed is almost certain, but there does not seem much reason to suppose that the distribution of conductivity would thereby be altered. It is to be noted that this Paper deals with the effects of continuous current only. Those of alternating currents require separate investigation.

ELECTROLYTIC SYNTHESIS OF DIBASIC ACIDS.†

BY PROF. CRUM BROWN AND DR. JAMES WALKER.

When potassium ethyl malonate is electrolysed in strong aqueous solution there occurs at the positive electrode, besides actions resulting in the evolution of oxygen, the following synthetic reaction :—

$$2EtOOC.CH_2.COO. = EtOOC.CH_2.CH_2.COOEt + 2CO_2.$$

Thus from malonic acid there is obtained succinic acid, the next member in the series of saturated dibasic acids. In the same way there may be obtained from succinic acid adipic acid ; from adipic, sebacic ; from glutaric suberic ; and from suberic and sebacic acids two new acids of the formulæ $HOOC.(CH_2)_{12}.COOH$ and $HOOC.(CH_2)_{16}.COOH$. Acids with side chains behave in a similar manner, thus from methyl malonic acid there are obtained the two inactive symmetrical dimethylsuccinic acids. Amongst the other products of the electrolysis there are found ethyl ethers of unsaturated acids, for instance, acrylic ether in the case of the electrolysis of pthyl potassium succinate. The formation of this substance may be represented by the following equation :—

$$EtOOC.CH_2.CH_2.COO. \quad EtOOC.CH_2.CH_2.COOH$$
$$+EtOOC.CH_2.CH_2.COO. = +EtOOC.CH_2.CH_2 + CO_2.$$

The positive pole employed was a spiral of platinum wire, and the negative pole a platinum crucible of about 40 cc. capacity. The E.M.F. was 12 volts, the current being about 4—5 amperes.

* Abstract of a Paper read before the British Association in Section D, Edinburgh, August, 1892.

† Abstract of a Paper read before the British Association in Section B, Edinburgh, 1892.

LEGAL INTELLIGENCE.

Clegg and Sons v. The International Okonite Company (Limited).

This action was brought by the plaintiffs, who are architects in Manchester, against the defendants, manufacturers of electrical wires and cables at Newton Heath, for professional services in connection with the erection of defendants' works. The defendants counter-claimed damages for alleged negligence. The case was heard last week at the Liverpool Assizes, before Mr. Justice Denman, who delivered judgment on Monday. His lordship said the claim was for £129. 13s. 3d., balance of commission earned and work done by the plaintiffs, and the question was, had the plaintiffs made out that they were entitled to remuneration at the rate of 3 per cent. commission, which was claimed, or at the rate of 2½ per cent. He thought that they had made out that part of their case, subject to any small deduction with regard to the amount on which the commission was to be claimed. The second item in the claim was for £73. 6s., which was for a good many things, such as preparing drawings, original surveys, &c., and he did not think this claim was other than a fair and reasonable one. With respect to the counter-claim, he did not find that the defendants had suffered any damage by reason of any negligence on the part of the plaintiffs. His lordship therefore gave judgment for the plaintiffs for the amount claimed on the claim and counter-claim, with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 6, 1892.

The Electrical Engineering Department of Cornell University.—The annual report of President Adams, of Cornell University, indicates that the electrical engineering department of that Institution is in a thriving condition. Since this department was organised about ten years ago by Prof. W. A. Anthony, the number of students registering each year has been constantly increasing, until in 1891 and 1892 the total number taking the studies in the electrical engineering department was 250. From 1884 to 1891 the number of students registered was 28, 40, 59, 83, 125, 172, 214, and 250. The graduates of the same department for the period 1886-1892 were 5, 7, 8, 19, 28, 28 and 46 for the respective years. During the past few years the department of physics under the charge of Prof. E. L. Nichols has carried on a great deal of original work, the results of which have been published in twenty-five different periodicals in the English, French, German and Italian languages. These Papers have been written by over thirty different authors, including professors, instructors and students.

An Automatic Telephone Exchange.—A rather ingenious apparatus for displacing operators in a central telephone exchange has been brought out by the Strowger Automatic Telephone Company of this city. This company is exhibiting at its rooms a model installation for the purpose of showing the method of working the system. The operation and the apparatus used are not at all complicated, and seem to perform the work for which it is designed with very little chance of failure. The apparatus is intended to enable any telephone subscriber to connect his instrument with that of another subscriber whose number he knows. Five keys are provided for each subscriber, namely, one key numbered units, another tens, a third hundreds, and a fourth thousands, while the fifth key is used to release the connection after conversation is finished. In case a number, say 131, is desired, the subscriber

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presses the unit key once, the tens key three times, and the hundreds once. The closing of the circuits in this way by these keys sets into operation a little instrument 4 × 4 × 6in. which each subscriber has in the central exchange in such a way as to connect his line with the line of the subscriber with whom he wishes to converse. No operators are required in the central exchange, and all the attendance necessary is whatever is needed to keep the apparatus in repair.

The Late Mr. Cyrus Field.—The will of Cyrus W. Field, made public this week, discloses the fact that the mementoes of the Atlantic Cable laying were not presented to the Metropolitan Museum of Art in this city, as had already been announced.

CORRESPONDENCE.

THE PHYSIOLOGICAL EFFECTS OF ALTERNATING CURRENTS OF HIGH FREQUENCY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of July 8th, 1892, in commenting upon my Paper, an abstract of which was published in the *Electrician*, Vol. XXVI., p. 644, on the "Physiological Effects of Alternating Currents of High Frequency," you say, "but not a hint was given about the methods of measuring such currents."

It is but just to Dr. Tatum, who died shortly after writing about his experiments, the results of which were given in his letter to me, and published under the above title, to say that it is my impression he wrote me that in measuring the high frequency currents he used a hot wire ammeter, which he had already used in his experiments of 1890, to which you refer. In his experiments on the physiological effects of high frequency currents he used currents of 4,500 alternations per second, and found that a greater strength of such currents could be more readily borne by a dog than if the current were continuous.

You quote Prof. E. J. Houston as saying that "at extraordinary high frequencies all harmful physiological effects practically disappear." I would remark on this statement that it may be true, but it is not proven. Dr. Tatum's results point to the fact that it is probable, that as the frequency increases, a larger and larger current would be required to produce injury, but it is well known that the discharges of a Leyden battery are of extraordinarily high frequency, but it can hardly be claimed that such an oscillatory discharge continued for a moderate interval of time would be without harmful effect. A considerable size of battery may be discharged through a person without necessarily injuring him, although the shock will be violent. The absence of injury in this case may be, and probably is, due to the fact of the extremely brief duration of the discharge. Permit me to suggest that the superior immunity from harmful effects when high frequency currents are passed through the body may be, at least in part, due to some other influence than mere "skin" effect. May not the fact that the living molecules have some chance of recuperation or restoration during the zero periods or times of practically no current passing, which with high frequency currents are increased in number and are nearer together, account for the effect noticed aside from the peculiarities in the distribution of the currents?

In my correspondence with Dr. Tatum before his death, this resting of the molecules at the zero points was suggested by myself as the probable cause of the comparative immunity found, and there may, of course, be some property akin to sluggishness of effect upon these molecules which would lessen the harm in the case of very high periodicities. If the high period current traversed the body mostly by the surface, or skin, then the sensation ought to be greatly increased over what is found with a lower period, or with continuous currents; but Dr. Tatum found in his experiments that there was very little difference to be detected in the degree of sensation or unpleasantness of the currents of various periods. From the fact that much of the fatty tissues of the body underlies the skin, and that the outer skin is a comparatively poor conductor, it would seem that a considerable portion of any skin effect would be neutralised, and the current, unless the frequency were indeed extraordinarily high, would be distributed over the body in a measure in accordance with the conductivities of the tissues, which in turn would depend largely upon the proportion of dissolved salts contained, and the absence of fat.

It seems to me that we need an extended course of experimentation to be pursued in this field before we are able to say anything as to the causes of the undoubted difference of effect observed between currents of different periods on the animal organism.—Yours, &c.,

ELIHU THOMSON.

Lynn, Mass., July 26, 1892.

CARBON BRUSHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a contribution to the recent correspondence in your columns on the subject of carbon brushes, I beg to say that when a low-tension dynamo is fitted with several pairs of copper brushes of ample capacity, good results can be obtained by substituting carbon for one brush on each side, and setting the carbon brushes a trifle in advance of the copper brushes. The copper brushes take care of the current while the carbon suppresses the spark. The adjustment of brushes when starting the dynamo to position of least spark, should be made with copper brushes only: the carbon brushes being dropped on to the commutator after the best position is found.

I adopted this expedient some time ago on a dynamo which had a variable load and attendance of the poorest kind. It was such a success in preserving the commutator that I apply it wherever I have a variable load. For constant-potential dynamos of E.M.F. higher than 220 volts, American practice is to use carbon brushes exclusively. And for motors of 220 volts most manufacturers furnish carbon brushes. These 220-volt motors up to 50-H.P. are very largely used on Edison 3-wire circuits, and almost always with carbon brushes.—Yours, &c.,

D.

Chicago, Ill., August 3, 1892.

THE WESTMINSTER ELECTRIC SUPPLY CORPORATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As many of your readers will have learned of the total extinction of the electric light at the St. Stephen's Club on the evening of the 9th instant, I should feel greatly obliged if you would kindly allow me to contradict in your columns a report which has gained ground, to the effect that the extinction was due to a failure of supply by this corporation.

The misapprehension is due to the fact of the club in question having been lighted for some months, and that without any interruption whatever, by current supplied by this Corporation, until about six weeks ago, when the committee of the club decided to avail themselves of an offer from another source at a cheaper rate, with the result above stated.—Yours, &c.,

EDMUND BAX, Manager.

Victoria Mansions, Victoria Street, S.W.,
August 17, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Oldham Corporation require tenders for making and fixing concrete culverts and the laying of electric conductors, and also for the supply of cast-iron pipes and service boxes. Specifications and drawings can in each case be obtained on payment of a guinea (returnable), on application to Prof. Alex. B. W. Kennedy, 19, Little Queen-street, Westminster, S.W., or to Mr. A. Nicholson, Town Clerk, Town Hall, Oldham, to whom tenders must be delivered by September 2nd.

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TENDERS INVITED.—The Corporation of Derby require tenders for the construction of Lancashire boilers and accessories for their central lighting station. Plans may be seen on application to Messrs. Bramwell and Harris, engineers, 5, Great George-street, Westminster, S.W., or to the Town Clerk, Town Hall, Derby, from whom may be obtained specification and form of tender. Tenders must be delivered to Mr. H. F. Gadsby, Town Clerk, Town Hall, Derby, by 12 noon on 22nd inst.

——— Tenders will be received until March 31, 1893, by the civil authorities of Bougie, Algeria, for the lighting of the town either by electricity or gas.

——— The Municipality of Graz will receive, up to 12 noon on August 31st, tenders for the erection and installation of a central electric light and power station.

TENDERS ACCEPTED.—The Prescot Local Board met on Tuesday to consider revised estimates submitted for lighting the town. The Prescot Gas Company offered to light the public lamps with gas at a total cost of £307. 7s. 8d. per annum; but an offer from the British Insulated Wire Company (Limited) to light the streets by electricity for an annual sum of £350, was unanimously accepted. The Company agree to supply electric light to the existing gas columns (70) with incandescent lights of 12 c.p. during darkness the year round; 10 arc lamps 2,000 c.p., and two arc lamps with 500 c.p., from dusk to midnight; and the Local Board will support the Company in an application to the Board of Trade for a licence under the Electric Lighting Act, 1888, to supply light to private consumers.

——— The Guardians of the Chertsey Union have accepted the tender of Messrs. J. Hamilton and Son, Guildford-street, Chertsey, to construct telephones, electric bells, and speaking-tubes at the Workhouse at Ottershaw for £33.

——— The tender of the Roper Electrical Engineering Company has been accepted for wiring the Bradford Town Hall for electric lighting.

——— The tender of Messrs. Peirson and Co. has been accepted for the supply and erection of the constructional iron work for the Meredith's Wharf Depôt of the City of London Electric Lighting Company (Limited), the amount of the contract being £2,896.

——— Messrs. Lowdon Bros. have secured the contract for installing the electric light to the works of Messrs. A. and J. Macnaughton, Pitlochry.

TENDERS RECEIVED.—At the last meeting of the Walsall Town Council the General Purposes Committee reported that 28 tenders had been received for lighting with electricity a portion of the borough, such tenders ranging from £6,712 to £22,733, and that the Electric Lighting Sub-Committee would visit five or six towns where systems of electric lighting were in operation for the purpose of gaining information.

——— The Electric Lighting Committee of the Yarmouth Town Council have received six tenders for lighting the borough, the lowest of which was between £5,000 and £6,000, and the highest over £23,000.

PREMISES TO LET.—The Westminster Electric Supply Corporation (Limited) advertise elsewhere particulars of some vacant land with workshops erected thereupon, which are to be let, in the S.W. district.

COATBRIDGE.—The Scottish House-to-House Electricity Company (Limited) are about commencing the erection of a central station, and have placed the contract for the machinery in the hands of Messrs. J. E. H. Gordon (Limited).

DUBLIN.—The electric light fittings, the wiring for the electric light, and the telephones (77 in number) in the Hotel Métropole, just opened, were installed by the Electrical Engineering Company of Ireland (Limited), under the superintendence of Mr. Walter Leake.

MR. A. A. C. SWINTON.—This gentleman is installing the electric light at Newbold Revel, the seat of Mr. H. E. Wood. The plant will comprise two Cornish boilers, two Parsons steam turbines and dynamos, a large battery of D.P. accumulators, and some 500 incandescent lamps.

MESSRS. CARRICK AND RITCHIE.—We have received from this firm some illustrated particulars, with price lists, of their well-known Waverley turbines, jet water motors, &c.

TATE'S ELECTRIC VALVE CLOSING APPARATUS.—We are informed that Mr. S. P. Wood, of Hull, has been appointed district agent for this apparatus, by which motive power can be shut off immediately in case of accident.

THAMES ELECTRIC AND STEAM LAUNCH COMPANY.—Mr. Andrew Pears has taken over the Electric and Steam Launch Buildings and Public Charging Station, now in course of construction upon Eel Pie Island, Twickenham, formerly the property of Mr. W. S. Sargeant, of Strand-on-the-Green, Chiswick and Twickenham, and the firm in future will be worked as the "Thames Electric and Steam Launch Company." The whole of the buildings, which have been designed and laid out with the intention of carrying on a very extensive launch building works, and to manufacture everything appertaining to water propulsion, both electrical and steam, consist of two large shops two stories high, one for boat building and joinery, and the other for engineering and electrical work: in addition to these there will be a building having 84ft. span for housing launches, &c., and general repairs. In connection with this a slipway is being fitted complete with a single, double and treble geared hauling winch, driven by an electric motor; this will haul up any size vessel that can navigate the Upper Thames.

POOLE AND WHITE (LIMITED).—A petition for the winding-up of this Company has been presented by Messrs. J. G. Rollins and Co., Old Swan Wharf, Upper Thames-street, E.C., and will be heard by Mr. Justice Vaughan Williams on Wednesday next, the 24th inst.

ATELIERS HOSTER DE ST. NICHOLAS (LIMITED).—An order for the compulsory winding-up of this Company was made on the 11th inst.

MR. RANKIN KENNEDY.—The examination of this bankrupt is to take place at Sheriff Spen's Chambers, Glasgow, on Monday next, the 22nd inst., at 11 o'clock a.m.; and a meeting of creditors is to be held at 82, West Regent-street, on the 31st inst., at 12 o'clock.

FRENCH ELECTRICAL COMPANIES IN LIQUIDATION.—The Compagnie Parisienne d'Eclairage par l'Electricité is being voluntarily wound up.—Messrs. Martin, Ducamp and Co., makers of the "Bimetallic" telephone and telegraph wire, with offices in Paris and works at Joinville-le-Pont, is also in liquidation.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

July 12, 1892.

12,888. L. VON ORTH and E. PRESLAUER. London. Improvements in electrical regulating devices for clocks.

July 14, 1892.

12,906. W. M. HADDOW and J. S. HUTCHISON. Glasgow. Improvements in and relating to "roses" or electrical connections for the ceilings of buildings or structures.

July 15, 1892.

12,977. C. A. BURGHARDT. Manchester. Improvements in the electrolytic production of caustic soda or caustic potash.

12,999. G. KAPP. Manchester. Improvements in the method of and means for distributing electric currents.

July 16, 1892.

13,072. D. RYLANDS and S. SLATER. Barnsley. Improvements in coupling and fixing glass tubes for containing electric wires.

13,090. W. HEDGES. London. Improvements in portable electric lamps and safety fuses for same.

13,095. F. VON POSCHINGER. London. Improvements relating to the electric heating of pottery, and other furnaces and materials therefor.

July 19, 1892.

13,160. T. ODDY. Rochdale. Increasing the efficiency of telephonic communication and transmitting speech.

13,167. W. E. IRISH. London. Electric arc lamp.

13,207. L. STIRN. London. Improvements in incandescent electric lamps.

13,221. W. DECKERT. London. Improvements in or connected with telephones.

July 20, 1892.

13,297. W. W. HORN. London. Improvements in electropathic appliances for human wear. (R. S. Mears and W. C. Powers, United States.)

12,288. H. HIRST. London. Improvements in connections for electroliers and other electric light fittings.

July 21, 1892.

13,323. H. C. BULL and G. B. COWL. Liverpool. Improvements in or connected with the production of electric energy.

13,335. T. WHITTINGHAM. Birmingham. Improved means for signalling by electricity on railways.

13,337. G. W. HANNAM. London. Improvements in electric belts, which improvements are also applicable to other purposes.

13,375. W. L. SPENCE. Manchester. Improvements in or relating to electric meters, recording apparatus, and controlling gear.

13,380. F. B. BEDWELL. London. Improved means of preventing injury to telegraph cables connected with lightships and floating stations.

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July 22, 1892.

13,381. E. B. Bright and L. W. Mercier. Surrey. Improvements in the manufacture of electrical storage plates, cells, or accumulators, and the accessories thereto.

13,395. M. Mercier. Manchester. Improvements in or relating to electrical apparatus for signalling.

13,405. H. Nehmer. London. Improvements in portable Leclanché batteries.

July 23, 1892.

13,453. G. Bamberg. London. Improvements in electrodes for use in electrolytic apparatus, and in their manufacture.

13,473. G. Binswanger. London. Improvements in apparatus for heating purposes, and cooking by means of electricity.

July 25, 1892.

7,404A. S. H. Short. London. Improvements in or relating to dynamo-electric machines and electric motors. (Date claimed under Patents, Rule 19, April 19, 1892.)

13,507. W. H. Scott. Norwich. Conduits with insulators for underground conductors for the distribution of electricity.

13,541. F. E. Elmore. London. Improvements in the manufacture of continuous lengths of tube by electrolysis.

13,542. F. E. Elmore and A. S. Elmore. London. An improvement in tanks or cells for electrolysis and like purposes.

13,543. Siemens Bros. and Co. (Limited). London. Improvements in electrical installations for producing alternate currents. (Siemens and Halske, Germany.)

13,549. F. V. Andersen. London. Improvements in dynamo-electric machines.

13,557. W. P. Thompson. Liverpool. Improved system of electric traction for railway trains, tramways, and the like, and apparatus in connection therewith. (La Société Anonyme pour le travail electrique de métaux, France.)

13,559. J. Cerpaux. London. An improved telephonic plant for private and domestic use.

July 26, 1892.

13,562. D. Young. London. Improvements in and relating to electrical accumulators for secondary batteries. (A. E. Colgate, United States.)

13,595. J. A. Ewing and C. G. Lamb. Cambridge. Improvements in apparatus for varying the strength and direction of electrical currents.

13,619. W. H. Munns. London. Improvements relating to electrical fire-alarms and the like. (A. H. Brintnell, Canada.)

13,639. A. S. Simpson. London. Improvements in acoustic telephones.

13,648. M. W. Dewey. London. Improvements in electric railways.

July 27, 1892.

13,678. W. R. Webb. London. An electric combination contact bell-push and pull.

13,683. T. R. Andrews and T. Preece. Bradford. Improvements in the method of and apparatus for starting electric motors.

13,694. W. C. Johnson and T. Boyden. London. Improvements in alternate-current transformers.

13,698. F. E. Elmore and A. S. Elmore. London. Improvements in the treatment of mandrels for electrolytic deposit of metallic tubes.

13,702. T. Puskas. London. Organisation and arrangement of a telephonic news transmitter.

13,718. H. L. Doulton and C. E. Morris. London. Improvements in conduits for electric mains and in laying the same.

July 28, 1892.

13,763. J. B. Lee. London. Improvements in incandescent electric lamps.

13,764. J. B. Lee. London. Improvements in the construction of secondary batteries.

13,765. M. Hutin and M. Leblanc. London. Improvements in alternate-current electro-dynamic machines.

July 29, 1892.

13,850. Sir C. S. Forbes, Bart. London. Improvements in incandescent electric lamps and in apparatus connected therewith.

13,854. C. F. Rowley. London. Improvements relating to the application of electricity in connection with chairs, known as "dental chairs," for carrying out dental and other surgical operations.

July 30, 1892.

13,856. G. Binswanger and H. J. Coates. London. Improvements in electric bells.

13,879. E. W. L. Harrison and S. Murray. Manchester. Improvements in telephone receivers.

13,892. R. F. Mann, J. Purvis, and A. R. Burman. London. Improvements in appliances for producing galvanic action for curative purposes.

13,894. W. H. Preece. London. Improvements in submarine telegraph cables.

13,919. E. Thomson. London. Improvement in incandescent electric lamps.

13,920. W. H. Knight and W. B. Potter. London. Improvements in methods of regulating electrically-driven mechanism and apparatus for putting the same into operation.

August 2, 1892.

13,932. J. W. Yates and H. T. Yates. Sheffield. Improvements in telephone switch boards.

13,989. J. W. Gibboney and E. Thomson. London. Improvements in telephones.

13,996. W. Henry. London. Improvements e.ectrical generators.

August 3, 1892.

14,035. J. Pinter. London. An improvemen: n electric incandescent lamps.

14,043. W. J. H. Jones. Liverpool. Improvements in arc lamps.

14,044. J. C. Fell. London. Electrodes for secondary batteries. (W. Morrison, United States.)

14,056. H. H. Lake. London. Improvements relating to electric motors. (W. Stanley, jun., and J. F. Kelly, United States.)

14,060. A. I. Gravier. London. Improvements in dynamo-electric and electro-dynamic machines.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

5,790. Boehm and Bailey. Incandescent electric lamps.

11,108. Coad. Electric batteries.

11,447. Norman and Payne. Electric arc lamps.

11,538. Prokofiew. Conductors for electric propulsion on permanent way.

11,630. Bower. Ribbed metallic plates for secondary batteries.

11,891. Thompson (Dietz). Telephone switch devices.

12,019. Wise (the Rheinische Fabrik für Elektrische Bogenlichtkohle; W. Grüdelbach). Carbons for electric arc lamps.

12,150. May. Magneto-electric time-pieces.

13,362. Forbes. Dynamo-electric machines.

13,384. Forbes. Electrical contacts.

14,040. Lake (Orling). Electric lighting, &c., apparatus for gas burners.

14,097. H. L. and J. Todd. Telephone transmitters.

14,236. Low and Pritchett. Generating and distributing electricity.

14,266. M. and A. E. Humm. Administering electricity to horses.

14,854. Cannot. Insulating electrical conducting wires, &c.

15,050. Le Sœur. Electrolysis.

15,214. Harper. Telephone receiver.

15,243. Wells. Electrical chronographic apparatus.

15,407. Cohen. Galvanic batteries.

15,483. Mewburn (Sée). Electric lighting.

15,579. March. Electric switch and cut-out.

15,697. Graham. Electric telephone transmitters.

15,872. American Elevator Company (Otis Bros. and Co.). Electric motors, &c.

17,426. Andreoli. Generating ozone by electricity.

18,272. Chadwick. Electric belts.

1892.

785. Ries. Incandescent electric lamps, &c.

3,654. Richter. Electric burglar alarms.

4,010. Lockwood. Telephone apparatus.

4,617. Feldkamp and others. Electrical attachments for pianos.

6.007. Parker and Robinson. Cells for electrolysing chloride solutions.

7,509 Lake. (Stanley and another). Alternating-current electro-magnet motors.

9,056. McKay. Electrically giving reciprocating motion.

9,343. Burton. Electric connectors.

9,347. Kellner. Separating alkali from electrolyte.

9,356. Burton. Distributing electric currents.

9,362. Burton. Electric metal working apparatus.

9,365. Lundell and Johnson. Electric motors, &c.

9,379. Burton. Electrically heating and working metal bars.

9,409. Binns. Electromagnets for organs, &c.

9,815. Streeter. Foot supports for telegraph poles, &c,

9,883. Thompson (Coffin). Electric motors.

9,891. McKenna and Weed. Electric meters.

9,947. Hadden (Grammont). Electric conducting wires.

9,983. Thompson (Ries and another). Propelling railway vehicles by electricity.

10,133. Brandas. Electrical insulators.

10,230. Lord Kelvin. Electric condenser.

10,367. Sanche. Connections and terminals for electric wires, &c.

10,715. Jackson. Electrical conductors.

10,762. Weaver and Manypenny. Electric lamps.

10,850. Weymersch. Primary voltaic batteries.

10,870. Lake (Weston). Electrical measuring instruments.

11,032. Harris. Insulating supports for electrical conductors.

11,119. Broadnax. Electric switches.

11,147. Lloyd. Secondary batteries.

11,154. Thompson (Coffin). Welding metals electrically.

11,316. Van Vianen. Electric alarums.

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COMPANIES' MEETINGS & REPORTS.

Cuba Submarine Telegraph Company (Limited).

The forty-second ordinary general meeting of the Cuba Submarine Telegraph Company (Limited) was held at the Company's Offices, No. 58, Old Broad street, London, on Wednesday, August 17th, 1892. "to receive the Directors' report and accounts for the half year to 30th June, 1892, to elect a Director and auditor in the room of those who retire, and to transact the other general business of the Company." The chair was occupied by Thomas Greenwood, Esq.

The CHAIRMAN, in opening the proceedings, said: The Secretary will read the notice calling the meeting.

The SECRETARY (Mr. James Scott) having read the notice,

The CHAIRMAN said:—Gentlemen, the Directors have much pleasure in asking your approval of the report and accounts which are submitted to you to-day. They are as favourable, I think, as any which have preceded them, and they cannot fail to meet with your approval. The income has been rather larger than in the corresponding period of the previous year—about £1,100, but this has not arisen from any increase in the general run of the traffic receipts; but it appears the larger, because during a part of the half year with which we are now comparing the lines were interrupted for a little time. The expenditure also is a little less. That is rather an unusual thing, because with companies that are growing we generally find that the outlay grows with them; but taking the whole together the expenses were in the half-year now under consideration £5,436, or a difference of £80, compared with the corresponding period of the previous year, and that is after making rather an unusual charge for depreciation on stores and cable in stock. You will observe that that amount is £984 for the half-year—rather a large sum. I am not at all sure that it is not too large, but the Board has thought best to err on the safe side, and to bring down our assets to a fully realisable value. Fortunately for us, there has been no interruption of our cables this half-year, and the result is that having no repairs to do we are enabled to increase the reserve fund unusually to meet requirements of the kind which may happen in future periods. Therefore, we have a large sum of £7,000 to add to our reserve fund, which brings it up to £90,000, as compared with £78,000 in the corresponding period of the previous year. The half-yearly payments, I may remind you, regarding the Cienfuegos-Santiago cable of 1881 have now nearly ended. We shall have to make a similar charge in the half-year now current to December next, and a few pounds—about £400 or £500—in the next half-year. It may, perhaps, be desirable to end the whole charge next half-year, and bring in a few hundred pounds to close the whole thing. That charge will then cease to be paid by the Company, and the whole of the cable will then belong to the Company, and will be at their cost to repair instead of the contractors. The feature of the report which is unusual is paragraph No. 5, which relates to the change in the Directorate. Mr. Neil Bannatyne, who was one of the first Directors of the Company, and with whose face you will have been familiar, died some little time since, and the Board had to look about for some one to take his place. At that time Mr. Keith, who has been the manager of our works in Cuba for over fifteen years, was in England, and had intimated his wish to remain in England, and not to go back again to Cuba. The Board at first thought it would be an unwise thing to lose Mr. Keith's services abroad, because they had been so very valuable to us; but Mr. Keith gave us fairly to understand that he would continue to take the same supervision in our cables on the other side, although he might reside in England, as he had hitherto done, and the Board made an arrangement with him, the details of which I will give you presently. It is not necessary to ask you to pass a special resolution; but the Board always feel very anxious, whenever any payment is to be made to them, that the shareholders should be fully acquainted with it. You see a statement in the revenue account of £450, which the Directors receive, and they receive nothing more on any account whatever, whether for travelling or any other expenses; and, therefore, as we wanted to make an additional payment to a Director, we thought it right to inform you. We have made an arrangement with Mr. Keith that, in addition to the £200 which he will get as Director's fees, he shall receive a further sum for taking entire supervision of the cables on the other side as before, and the responsibility of looking after them through the help of one of our servants on the other side. Further than that, I may say that in the event of the cables requiring repair, Mr. Keith has undertaken to go and repair them, receiving during the time he is away from England the same salary he would have received as general manager on the other side. Altogether we have effected a considerable saving, and under these circumstances I think you cannot fail to approve of what the Board has done. If there be any other item in the accounts or the report on which the proprietors desire information, we shall only be too pleased to give it; but pending that, I move—

"*That the report and accounts for the half-year ended June 30th last, now submitted, be received and adopted.*"

Mr. CHARLES W. PARISH: Gentlemen, I have very great pleasure in seconding the motion which the Chairman has just put to you. He has entered so fully into all the matters of interest that we have before us that it is unnecessary for me to enlarge upon what he has already said. I therefore beg to second the motion.

The CHAIRMAN put the motion, and it was carried unanimously.

In reply to Mr. LYDDON, the CHAIRMAN said he could add nothing to the statement in the report respecting the suit against the Spanish Government; and he then proposed—

"*That the following dividends for the half-year be now declared on the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income tax, on the preference shares, and 8 per cent. per annum, free of income tax, on the ordinary shares, payable on and after to-morrow.*"

Mr. KEITH: I beg to second that.

The motion having been carried *nem. dis.*, Mr. Charles Woodbyne Parish was re-elected as Director and Mr. John Gane was re-elected auditor, and the proceedings terminated with a vote of thanks to the Chairman and Directors.

The Pioneer Telephone Company (Limited).

An extraordinary general meeting of this Company was held on Tuesday last, at Winchester House, Old Broad-street.

The SECRETARY (Mr. J. Cecil Bull) having read the notice convening the meeting,

The Duke of MARLBOROUGH, who presided, said that the Company was formed for the purpose of initiating a new departure in the important industry of telephony, and was extremely well responded to; and he was glad to think that those persons who invested their money in the enterprise were able to realise what, he was sure, they would consider to be a very reasonable profit, having regard to the risk incurred. It was said at the time by certain organs of the Press that the Pioneer Company was simply a sort of *ballon d'essai* for the purpose of finding out what the possibility was of establishing a rival competition to the existing Company. The real object of the Company, however, was to benefit the shareholders and to aid in improving the telephonic system of the metropolis. He had no reason for going back upon that, because he thought that the aims of the Company had been carried out. The Pioneer Company, during the course of its existence, did a lot of very useful work. It made a series of contracts of a very important character, and with a view to a complete London system, it entered, further, into contracts with a company at Manchester, which it acquired. It was, therefore, the possessor of a going concern; and even if the issue of the larger company had been delayed, the Pioneer Company would still have been a good investment for the shareholders, inasmuch as they were in possession of a substantial undertaking in the business of Manchester, which was purchased by the New Telephone Company. It would, perhaps, be hardly opportune for him to enter upon a discussion of the objects of the Company which had been aided by the Pioneer Company, and he would confine himself to a reiteration of the fact that the purpose for which the Pioneer Company was formed had been accomplished. The New Telephone Company had now a real existence, and he might say, speaking very positively, that it would be the means of producing a great improvement in the service of the metropolis, and, in affiliation with the efforts of the National Company, of extending this valuable invention of telephony in other parts of the United Kingdom. The advantage to the shareholders in the New Telephone Company was considerable, by reason of the fact that an alliance of a working character between the National and the New Telephone Companies had been arrived at. There would be no waste of capital in establishing rival systems, while at the same time the demand for this new invention was so large and the field was so vast that there was plenty of scope for the capital of both enterprises. From a public point of view, an advantage also arose, and this was that instead of there being two rival groups of subscribers in different towns, or in the metropolis, subscribers to the one system would be able to talk through the other; and brokers and others would not be obliged to have two instruments belonging to two companies in order to speak to persons possessing the commodity of a telephone. He thought that he would justify the resolution which he was about to put by simply stating what had been achieved, viz., the capitalisation of the New Telephone Company, for the purpose for which the Pioneer Company was originally formed. He now begged to move:—

"*That the Company be wound up voluntarily.*"

Mr. H. PEMBERTON LEACH seconded the motion.

The CHAIRMAN, in reply to Mr. C. EMMOTT, said that the Articles of Association of the New Telephone Company were reconsidered and amended at a general meeting held in the early part of this year, everything being carried out strictly in accordance with the law. The profit of the Pioneer Company largely depended on the success of the issue of the capital of the New Company. When they bought the Manchester undertaking they became the possessors of a paying concern at the time at which it was purchased. They had got 20 per cent. profit on an investment which offered no risk. The sum named as the purchase price of the Pioneer undertaking by the New Telephone Company would cover all contingencies.

The resolution was then agreed to.

Mr. A. A. C. SWINTON moved:—

"*That the Directors be paid the sum of £1,000 by way of remuneration for their services, divisible in such manner as they may determine.*"

Mr. MACKWORTH PRAED seconded the motion, paying a warm tribute to the ability displayed by the Chairman and Directors in conducting the affairs of the Company in the past, as well as in carrying out the negotiations for the larger undertaking.

The CHAIRMAN having briefly expressed his acknowledgments, the proceedings terminated.

Liverpool Overhead Railway Company.

The eighth half-yearly meeting of this Company took place on Tuesday in the Law Association Rooms, Cook-street, Liverpool; Sir W. B. Forwood, Chairman of Directors, presiding.

The CHAIRMAN, in moving the adoption of the report, said that of the total length of railway, comprising 582 spans, all but 35 had been erected. Of these 35, ten were required at the North-end and 25 at the South to

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complete the entire structure. The material for the parapet and railing which would surmount the structure had already been delivered in Liverpool, but it could not be placed in position until the completion of the laying of the girders. Stations Nos. 3, 4, 5, and 6 had been completed, Nos. 8 and 9 would most likely be finished next week, and the remaining ones were in a forward condition. The permanent way had been laid close to the last girder. At the Wellington Dock the heavy parts of the engines were in place, and would be completed next week, and it would take six weeks or two months to complete the engines. The rails were being placed in position, and other departments were in progress, and they were doing all they could to have the railway completed towards the end of October or beginning of November. He had tried to press the engineers to give them a definite date for the opening. The engineer did not care to do so, but saw his way to having it opened within two or three months. Mr. Cottrell, the gentleman whom they had appointed to manage the railway when completed, an engineer of whom they had the very highest opinion, and who had been working upon the construction of the line for the past eighteen months, was at present in America ascertaining the most efficient and economical system of working by electricity, and he had already obtained some useful and valuable information. With regard to the prospects of the Company, the Chairman believed that the traffic of the line of docks 'buses had increased since the commencement of the Overhead Railway works, notwithstanding the slowness and other disadvantages of that mode of conveyance, so that this was very encouraging for the Company. The powers the Company were seeking, to extend the line to Crosby-road, Seaforth, at the North-end, and Park-road, at the South, had been obtained. The Directors had not received a single application from a shareholder for one of the recently-issued bonds, and the Chairman said he thought the Directors had been well advised to accede to the very advantageous offer of the Bank of Liverpool to place the whole at once. The bonds were taken by the bank at par, the Company paying 1½ per cent. to cover brokerage and all costs of issue.

Mr. R. HOBSON seconded the motion, which was carried; and the proceedings terminated.

Birmingham Central Tramways Company (Limited).

The following is the report of the Directors, to be presented at the general meeting to be held at the Queen's Hotel, Birmingham, on Wednesday next, the 24th inst., at 12:30 p.m.:—

The statement of traffic and profit for the year ending June 30th shows that the profits of the steam department have been materially reduced by the charge for fuel (part of which is exceptional) and by the repairs to engines. The electric department shows a loss chiefly due to the heavy charges for renewal of batteries; but your Directors have now under consideration a contract for maintenance of batteries, which, it is hoped, will tend to material economy and profit of working. The cable department has again shown a gratifying result, and it is evident that upon routes of heavy traffic and severe gradients no other system of traction at present in operation can compete with the steel rope.

The particular attention of the shareholders is directed to the diminution of profit consequent upon the consequent increase of the charges for maintenance, which, under the terms of the leases of the lines within the city as settled by our predecessors, we are bound to pay. How serious these are will appear from the following statements of the amounts paid in successive years:—1885-6, £249. 2s. 6d.; 1886-7, £654. 8s. 7d.; 1887-8, £739. 19s. 6d.; 1888-9, £1,935. 15s. 4d.; 1889-90, £4,683. 0s. 10d.; 1890-91, £5,058. 1s. 3d.; 1891-92, £6,593. 3s. 2d. It is quite clear that so large and increasing an expenditure can only be met by an increased revenue. After careful deliberation your Directors are of opinion that this increase of revenue can be earned by the conversion of the Stratford-road line into a cable line, which would be a source of great profit to the company and great convenience to the travelling public, and would increase the security of the Corporation. They have, therefore, with the concurrence of some of the largest shareholders, applied to the Public Works Committee of the Corporation to allow the expenditure of the whole, or part at least, of the sum of £68,580 (which the Corporation hold as security, and on the bulk of which they allow interest at the rate of 3½ per cent. only) to be applied for that purpose, and they recommend that the committee of the representatives of the shareholders may have authority given to them by the general meeting to assist your Directors in this matter.

The revenue account shows a balance of £17,659. 14s. 11d., to which has to be added the sum of £1,252. 3s. 9d., brought forward from last year's accounts, making together £18,921. 18s. 8d. Your Directors recommend:—(1) That the payment of the dividend upon the Five per Cent. Guaranteed Shares, amounting to £5,000, be confirmed. (2) That the balance of revenue account, amounting to £13,921. 18s. 8d., be carried forward pending the result of the application to the Corporation of Birmingham, above referred to, and also pending the decision of the shareholders as to any reduction of the nominal amount of the ordinary capital.

It has been represented to the Directors by many large shareholders that the time has arrived for reduction of the ordinary share capital from £10 to £5 per share. Diverse views appear, however, to be held upon the subject, and your Directors consider that the authority of the committee of shareholders might, with propriety, be extended to the consideration of this matter also.

Mr. M. J. Smith and Mr. W. Neale (two of the Directors) retire, and, being eligible, offer themselves for re-election. Messrs. Howard Smith, Slocombe and Co. offer themselves for re-election as auditors of the Company.

The working accounts show that the steam trams have run 1,212,624 miles, and carried 14,659,240 passengers, at a cost of a fraction over 1s. a mile; while the receipts have reached nearly 1s. 4d. per mile. The horse cars have earned 11·20d. per mile, and cost close on 10d. a mile. The miles run have been—tramway cars, 131,281; omnibuses, 503,270. Passengers carried—trams, 1,111,607; 'buses, 2,642,134. The cable cars have run 621,210 miles, carried 5,922,304 passengers, earned 12·20d. per mile, and cost 6·18d. per mile. On the Bristol road route the cars have run 188,760 miles, carried 1,382,997 passengers, earned 13·25d. per mile, and cost 15·39d. per mile. Net profit—steam trams, 3·93d. per mile; horse trams and 'buses, 1·24d.; cable, 6·02d.; loss on electric line, 2·14d. per mile. The steam trams have cost £13,155 in fuel and £10,652 in wages (apart from £5,106 paid as wages for repairs); the cable engines have cost only £1,538 in fuel, and £3,874 for the corresponding item of wages.

NEW COMPANIES, STATUTORY RETURNS, &c

COLLIER-MARR TELEPHONE AND ELECTRICAL MANUFACTURING COMPANY (LIMITED).—This Company was registered on August 10, with a capital of £100,000 in £10 shares. The objects are to acquire and take over as a going concern the business and undertaking of the Collier Audible Telephone Syndicate (Limited), and all or any of the assets and liabilities of that Company; with a view thereto to adopt and carry into effect the agreements referred to in Clause 3 of the articles of association (an agreement dated March 17, 1892, between the Collier Audible Telephone Syndicate, Limited, of the one part, and Ernest Hampson, on behalf of this Company, of the other part, as modified by an agreement made between the same parties, and dated August 5, 1892), and to manufacture, construct, erect, maintain, lay down, carry out, buy, sell, let out on hire or on lease, or otherwise deal in telephones and all apparatus and things connected with the establishment, working, and maintenance of telephonic communication or in connection with the generation, distribution, supply, accumulation, and employment of electricity, whether for the purpose of communication, light, heat, motive power, or otherwise, and in particular to construct, erect, sell, repair, and deal in telephones, cables, wires, lines, stations, exchanges, accumulators, and engines. The subscribers (with one share each) are:—Henry Matthews, Darley-street, Manchester; Hubert J. Owen, 14, St. Mary's-gate, Manchester; J. E. Pilling, 27, Leaf-street, Hulme, Manchester; George Graham, 19A, St. Clement's-road, Chorlton-cum-Hardy, Manchester; William Spencer, 322, Manchester-road, Hollinwood; Thos. Chapman, 311, Bolton-road, Pendlebury; William Frost, Spring Bank, Irlam's-o'-th'-Height, near Manchester. Unless otherwise determined, the number of Directors is not to be less than five nor more than seven. Some particulars relating to the issuing of the capital of this undertaking will be found in the CITY NOTES.

RENTON GIBBS AND CO. (LIMITED).—This Company was registered on August 10th with a capital of £10,000, in £5 shares, to acquire the business of heating and ventilating engineer, electrical engineer, &c., carried on at Liverpool and elsewhere by Robert Renton Gibbs.

SPERRYN, McDONALD, AND CO. (LIMITED).—This Company was registered on August 9th with a capital of £5,000, in £10 shares, to carry on in all its branches the existing business of James N. Sperryn, carried on by him at 181, Queen Victoria-street, London, E.C., and at 344, Newtown-row, Birmingham, and to carry on the business of manufacturing and dealing in brass and iron fittings for the electric light, gas, &c.

ELECTRICAL POWER STORAGE COMPANY (LIMITED).—The annual return of this Company, made up to August 3rd, was filed on the 9th. The nominal capital is £100,500, divided into 20,000 ordinary and 100 founders' shares of £5 each. At the time of making up 70 founders' and 18,537 ordinary shares had been taken up, of which 15,000 ordinary shares had been issued as fully paid. Upon the 70 founders' shares the full amount had been called, and upon the remaining 3,537 ordinary shares £3 per share had been called, resulting in the payment of £9,511, and leaving £1,450 as yet in arrears.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 14th were £721, as against £653 for the corresponding period of last year, being an increase of £68. The total receipts for half-year amount to £5,424, against £4,952 in the corresponding period of 1891, being an increase of £472.

COLLIER-MARR TELEPHONE AND ELECTRICAL MANUFACTURING COMPANY (LIMITED).—The prospectus of this Company has been issued. The Company is formed with a capital of £100,000, in £10 shares, 2,500 of which are allotted as fully-paid to the vendors in part payment of the purchase money, 2,500 are reserved for future issue, and 5,000 were offered to the public. The total price to be paid to the vendors for the patents and patent rights, and for the Manchester plant, stock in trade and works, which have been erected by the vendor syndicate, is £51,500; this is payable, £4,000 in cash, £25,000 in shares, and the balance partly in shares and partly in cash, or wholly in shares or cash, as provided by the contract. The Company claims for its patents many advantages over the instruments at present in use, one of which is that the patent receiver can be easily attached to existing telephones. The validity of the patents is certified to by Mr. J. Fletcher Moulton, Q.C., and the Company are

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enabled to commence work at once. Orders have already been received from the Post Office, the Canadian and Indian Telegraph Departments, the Great Northern Railway, the Corporation of Bradford, &c., &c. The list of applications opened on Tuesday last and closed yesterday (Thursday). The Directors are J. W. Maclure, M.P., Mr. Sheriff H. S. Foster, M.P., S. Chesters Thompson, J.P., H. T. Herford, and the patentees, Messrs. Arthur T. Collier and Alexander Marr. The Secretary (*pro tem.*) is J. W. Provis, jun., and the offices and works are situate at Derby-street, Oxford-road, Manchester.

ELECTRICITY SUPPLY CORPORATION (LIMITED).—The Directors have declared an interim dividend for the half-year ending June 30, 1892, at the rate of £5 per cent. per annum on the ordinary share capital of the Company, after payment of all interest on debentures.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 12, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,818.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated receipts of this Company for the fortnight ended August 15, 1892, were £1,982, compared with £1,630 for 1891, showing an increase of £352.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—The Board have declared an interim dividend for the half-year ending June 30th last at the rate of £3 per cent. per annum.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 10.		Price Wednesday, Aug. 17.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 17.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS								
£1,247,720	Stock	12/6	Anglo-American	47 48		47 48		5 10 0	Jan., Apr., July, Oct.	47¼	47
£2,876,140	Stock	25/0	Do. Preferred	87½ 88¼		87½ 88½		6 10 0	" "	88¼	87¾
£2,876,140	Stock	5/0	Do. Deferred	10¾ 11¼		10½ 11		..	" "	10¾	10½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 104		100 104		3 16 11	January and July ..	103	101½
130,000	£10	3/0	Brazilian Submarine	10½ 10¾		10½ 11		6 7 3	Mar., June, Oct., Dec.	11	10¾
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103		100 103		4 17 1	January and July ..	101½	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107		103 107		4 13 6	June and December	104¾	..
$7,716,000	$100	$1¾	Commercial Cable Capital Stock	160 165		160 165		4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12		11 12		6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18		17½ 18½		5 8 1	" "	18	17¾
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3¾		3½ 3¾		4 16 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10		9 10		5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½ 11¾		11⅝ 11⅞		6 0 2	Jan., Apr., July, Oct.	11½	11⅜
400,000	10	5/6	Eastern	14⅝ 14¾		14⅝ 15		4 6 8	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15¼ 15⅜		15¼ 15⅜		3 16 2	" "	15⅜	15⅛
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	109 112		109 112		3 11 5	May and November	111½	110⅜
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109		106 109		4 11 9	February & August	108½	107½
250,000	10	2/6	Eastern Extension	15 15½		15 15½		4 12 7	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111		108 111		3 12 9	February & August	110½	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106		103 106		4 14 4	January and July ..	105½	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105		102 105		4 15 2	" "	103	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104		101 104		3 16 11	February & August	102¼	..
180,227	10	3/0	Globe Telegraph and Trust	10 10½		10 10½		4 15 1	Jan., Apr., July, Oct.	10½	10⅜
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅝		15½ 15⅝		3 18 1	" "	15⅝	15½
150,000	10	5/0	Great Northern	18½ 19		18½ 19		4 9 6	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	107 110		107 110		4 10 11	March & September	..	..
17,000	25	1⅛	Indo-European	41 43		41 43		5 16 3	May and November	42½	..
38,348	10	4/0	London Platino-Brazilian	6 7		6 7		5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108 111		108 111		5 8 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8		7 8		5 0 0	April and October..	7⅞	..
3,381	£100 Cert.	£1⅞	Submarine Cables Trust 6%..37/6 Bal. Ap. Coup.	115 120		115 120		5 0 0	" "	118½	116½
15,609	10	5/0	West African Telegraph	6½ 7½		6½ 7½		5 6 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101 104		101 104		4 16 2	March & September	103½	..
30,000	10	2/0	West Coast of America	3 4		3 4		..	January and July ..	3⅜	3⅜
£150,000	100	8%	Do. Debentures 8% 1902	102 106		102 106		7 10 11	June and December	..	..
88,321	10	6d.	West India and Panama	1 1¼		1 1¼		..	" "	1⅞	1⅞
34,563	10	6%	Do. 6 per Cent. 1st Preference	9¼ 9⅝		9¼ 9⅝		6 3 1	May and November	9¼	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9		8 9		6 13 4	" "	8⅞	..
64,242	15	6/0	Western and Brazilian	8⅞ 9⅛		8⅞ 9⅛		6 9 7	" "	9	8⅞
33,129	7½	1/6	Do 5 per Cent. Cumulative Preferred	6 6½		6 6½		5 15 7	" "	6⅝	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2⅞ 3¼		2½ 3		..	" "	3	2⅝
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105		102 105		5 14 3	February & August	103	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105		102 105		5 14 3	" "	104⅛	103½
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122		120 125		5 12 0	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103		100 103		5 16 6	March & September	..	..
			TELEPHONES.								
£24,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜		⅛ ⅜		6 10 10	May and November	..	..
£20,000	£1	4½d.	Oriental (11s. paid)	⅛ ⅜		⅛ ⅜		7 18 2	Yearly	..	..
438,984	5	3/6	National	4½ 4⅝		4½ 4⅝		6 6 4	June and December	4⅝	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13¾ 14		13¾ 14¼		4 4 3	" "	14	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13 13½		13 13½		4 8 11	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109 111		109 111		4 1 1	January and July ..	110½	109⅝
58,000	5	1/0	United River Plate	1 2		1 2		..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95		85 95		5 5 3	—	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	9⅞ 10½		9⅞ 10½		..	—	10½	10
19,900	£5	..	Electricity Supply Co. of Spain	..		..		..	—	..	..
8,332	£5	..	House to House Electric	2½ 3½		2½ 3½		..	—	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5½		5 5½		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 5⅝		5½ 5⅝		..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16		3 7/16 3 9/16		..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16		5 1/16 5 3/16		..	March	..	..
111,000	5	..	London Electric Supply	⅞ 1		⅞ 1⅛		..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾ 7¼		6¾ 7¼		..	—	6⅞	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5		4 5		—	..	..	..
18,680	£5	2/6	St. James' and Pall Mall	7½ 7⅝		7⅝ 8		—	..	7⅞	7½
7,900	£5	7%	Do. 7% Preference	7⅞ 8¼		7⅞ 8¼		—	..	8 1/16	..
42,853	5	3%	Westminster Electric Supply (fully paid)	5¼ 6¼		5¼ 6¼		2 8 0	..	6⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	2⅞ 3¼		2⅞ 3¼		..	..	3	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅝ 2⅞		2⅝ 2⅞		5 1 1	..	2 1/16	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6		5½ 6		5 16 8	January and July ..	..	..
12,139	5	17%	Edison and Swan United	..		..		..	—	..	..
45,000	10	12/0	Electric Construction	4¾ 5¼		4¾ 5¼		..	—	5¼	5
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅝ 2⅞		2¼ 2½		—	—	2⅜	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3		2 3		..	—	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21 22		21½ 22½		5 11 1	February & August	21⅞	21¼
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106		104 106		4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3¼ 4½		2½ 3½		..	..	..	..
11,334	£10	8/0	Do. Preference	6 7		6 7		..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼ ⅜		¼ ⅜		..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3 3½		3 3½		11 0 0	May and November	3⅜	3⅜
37,350	12	12/0	Telegraph Construction and Maintenance	44 46		43 45		5 6 8	March and July....	44½	43½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106		103 106		4 14 4	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½ ¾		½ ¾		..	—	..	..
—	£5	8%	Do. Preference (fully paid)	2½ 3		2½ 3		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	—		—		..	..	..	..
50,000	£10	½	City and South London Railway	2⅜ 3½		2⅜ 3½		—	..	..	..

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THE ELECTRICIAN:

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NOTES.

From inquiries at the offices of the North Metropolitan Tramway Company we learn that the accumulator cars which have been running between Barking and Canning Town for more than four years, were suddenly stopped on the 28th of last month by order of the Board, and that the horse service has been resumed.

Accumulator work appears to be ill-fated, whether here or abroad, and no line seems able to live long. This is no doubt largely due to the inherent weakness of the system, but, we cannot help thinking that it is in some measure also due to indifferent financial management. It has been an open secret for years that the Barking electric line has not paid its way; and it is difficult to conceive how it could at 4½d., or even 5½d., per car mile.

At Birmingham also, as was shown in our Notes column last week, the financial results of the accumulator cars have proved unsatisfactory. During 1891-92 the total expenses of these cars have amounted to 15·39d. per mile run, while the receipts only reached 13·25d., leaving a loss of 2·14d. per mile run, or £1,679 on the twelve months' working.

A careful analysis and comparison of the detailed figures given both this year and last by the Birmingham Central Tramways Company, however, puts a different complexion on the matter. Permanent way repairs, which are, it seems, carried out by the Corporation, cost no less than £1,352 last year, or 1·72d. per car mile, as against 0·14d. during 1890-91; an enormous increase due to the Tramway Company having been charged, so we gather, with the wood paving of the entire route. Had this item remained at the same figure per car mile run this year as last, the cars would only have shown a loss of £487. Again, to the fact that the Corporation laid the rails 1½in. out of gauge may reasonably be attributed at least some of the increase of 4·47d. per car mile which is shown this year under the headings of "Electric Haulage" and "Machinery." Had this abnormal increase not taken place the accumulator cars would have shown a profit. It is, therefore, satisfactory to learn that the Birmingham Company does not despair, but has entered into a contract for the maintenance of the batteries at 1d. per mile run.

We publish this week the London County Council's By-Laws relating to Overhead Wires, as finally amended and approved by the Board of Trade. The complete metamorphosis which these much-discussed rules have undergone is at once a tribute to the efficacy of temperate agitation, and to the sweet reasonableness of the Board of Trade; and is, we might add, an indication of the doctrinaire spirit in which the rules were originally framed.

The principal alterations in the by-laws may be usefully summarised as follows:—Owners of existing wires are given six instead of three months' grace to comply with the requirements of the County Council. Instead of having to give a fortnight's notice *before* they erect a wire, companies need not now do so until one month *after*. The maximum span permissible under any circumstances is left open, and is not fixed at 140 yards. It is no longer obligatory to shackle the wires off at every support. The factor of safety for conductors has been reduced from 5 to 4; and although the factor for supports, &c., is retained at 10, the maximum possible wind pressure is taken at 30lb. per square foot, as against 50lb. originally. There is no external diameter limit to cables. Companies are no longer required to take down poles and wires within a month of their going out of use. The rule with regard to the admission of the emissaries of the parochial authorities into houses for purposes of inspection has been, as we have previously announced, almost whittled down into complete innocuity. Finally, four rules are altogether omitted, viz., that which prescribed a minimum angle of 60 deg. for all wires crossing a street; that which allowed no support carrying more than 10 wires to be used by more than one company; that which forbade any single support to carry more than 20 wires; and that which prescribed an efficient earth-connection or a lightning conductor for every pole. The by-laws have gained in weight what they have lost in length.

The record of the performance of two Ferranti continuous-current meters of the very earliest type, which we publish in another column, will be of interest in view of the recent Board of Trade Memorandum, which has been seized upon by the daily press and others as a peg upon which to hang damaging commentaries upon the reliability of electrical things in general. The wear and tear of the mechanism appears to have been an almost negligible quantity, and the constancy of the constant is by no means unsatisfactory when we take into consideration the date of the meters; 1885 is almost in the dark ages so far as electricity supply meters are concerned, so

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rapid has been their development. Mercury meters have, not without reason, been regarded by many with a considerable amount of suspicion; and it is satisfactory to find that actual experience, at any rate in the case of the Ferranti meter, does not warrant this distrust.

A somewhat sensational paragraph has been going the round of the French papers to the effect that a certain M. Willot has devised a relay which has enabled Paris and Algiers to be placed in direct telegraphic communication, and Hughes and Wheatstone instruments to be worked between these two points as easily as on long land lines. It is unnecessary to say that this is a consummation devoutly to be wished, but we hardly think the time for it has yet arrived. So far as our own information goes all that has been actually accomplished has been to work between Paris and Algiers for a time at about four words a minute. As much as this was done in 1879 by the late M. Ailhaud.

The essence of science is the correlation of facts. We cannot place one brick in a row, at least two are required; nor is there music in one note, though two may make harmony or melody. Similarly, one fact or experiment cannot be accepted as scientific until it is shown to be related to some other. The science lies in the relation, and not in the facts. The effect of an electrical discharge upon a photographic plate has been investigated by more than one experimentalist, but in no case with greater success than by Mr. Campbell Swinton.

The interest of his photographs lies in the difference between the positive and negative discharge; but the photographs tell us nothing but that a difference exists. The difference, which is clearly seen in the illustrations which will be found in another column, does not appear to be related to any of those few phenomena of polarity by which light may some day be thrown on the nature of electricity. Lichtenberg's figures are probably closely allied to these pretty patterns of Mr. Swinton. Until some relation is found between the characteristics shown by these photographs and some other electrical phenomenon, they can hardly find a place in electrical science; nevertheless, every contribution and investigation of this kind must eventually lead to or form the basis of more accurate knowledge, and in this sense they are undoubtedly of scientific value.

It would be difficult for the uninitiated to discover at first glance why the Chairman of the New Telephone Company should have occupied exactly one column of *The Times* of Tuesday last with a letter on the development of the telephone, a letter replete with generalities and well-worn commonplaces about the advantages of efficient telephone service, the backwardness of England, the forwardness of Sweden, and the wonderful advances which are now going to be made. General Webber, however, in a letter in *The Times* of the following day, went to the trouble of putting his finger on what was, of course, the only matter of public concern, namely, the complete *volte face* of the chairman of the New Telephone Company. The vehement representative of the discontent of the telephoning public, the advocate of competition and low tariffs and a telephone in every house, now lays every possible emphasis on the sad effects of competition in general, and of telephonic competition in particular, and on the desirability of high rates in order to keep down the demand for telephones, which, if too large, would prove inconvenient to our present telephonic purveyors. General Webber has done the public a good service in drawing their attention to the true-inwardness of this business.

Only a few weeks ago we remarked that train lighting by electricity presented few advantages over lighting by compressed gas, and observed that accidents from fire or explosion could be rarely attributed to the latter system. A correspondent writing from Buda Pesth subsequently called our attention to one or two rather serious fires; and on Saturday last, in the sad catastrophe at Clapham Junction, a man was burned to death and three coaches were burned to ashes through the ignition of the compressed gas. Several accounts mention an explosion. Experiments have been carried out on gas reservoirs of this kind, with the intent to cause an explosion, but the effect was only the immediate escape, and instant conflagration of the gas. This was, we believe, considered to be a satisfactory result, and the lighting of trains by gas was supposed to be free from danger. The burning of a passenger train appears to be the common sequel to a transatlantic railway accident, and is said to facilitate the clearing of the line; but the scene at Clapham Junction, even though a supply of water and a fire hose were at hand, will probably cause fresh attention to be paid to the possible use on passenger trains of the safest known means of illumination.

Ship Steering by Electricity.—The U. S. monitor "Miantonomoh" was steered by electricity during a recent voyage.

Vienna.—A concession has been granted for the construction of an electric tramway from the Prater to Kagran, a distance of nearly three miles.

The Telegraph in India.—A through telegraph wire from Calcutta to Madras is about to be erected. The length of the new line will be 1,900 miles.

Electric Traction in Belgium.—A Commission appointed by the Minister of Commerce and Public Works to consider the question has unanimously decided in favour of electric traction.

People's Palace Technical School.—Messrs. Slingo and Brooker will deliver courses of lectures on electricity, and other branches of electrical engineering, during the session commencing Sept. 28th next.

American Telegraph Operators.—Amongst the large number of organisations to be represented at a conference to be held in relation to the railway strikes in America is the Telegraph Operators' Union, which is 18,000 strong.

Central Institution.—The matriculation or entrance examination for the Central Institution will be held on September 19th—22nd; and the new session commences on September 28th. Further particulars will be found in our advertisement columns.

The Magnetic Observations of the World.—According to *La Lumière Electrique* there are only 33 magnetic observatories in all in the world. Of these, eight are in France and three in England. About one-half of the total number are provided with Mascart recording apparatus, the others have appliances of the Kew type.

The Cork Gas Consumers' Company.—At the last meeting of this Company the Chairman stated that they had again given notice to the Corporation of intention to apply for an Electric

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Lighting Order. They were, he said, satisfied that if the citizens wished to have the electric light no one could supply it so economically and so satisfactorily as they could.

The Crystal Palace Exhibition.—"We believe," says *Industries*, "that, taken all round, the Crystal Palace Electrical Exhibition of 1892 has done as much for the progress of the electrical industry as the Exhibition of 1882, and that is saying a great deal. There may be dissatisfaction as to the awards, but there are always complaints of that sort, and anyone who knew the Exhibition will acknowledge that on the whole substantial justice has been done."

Errata.—On p. 430 of our last issue the sentence preceding the table in Prof. Cargill Knott's Paper "On Certain Volume Effects of Magnetisation," should read:—"The numbers are the greatest measured values of the changes of volume. . . ." In the table itself the two last figures in the column headed "Iron Tubes, High Field," should read -37 and -24. The second sentence after the table should read:—"In field 1,000 the dilatation amounted to -6×10^{-6}."

Thunderstorms.—On Thursday, last week, the United Kingdom was visited by a very severe storm, which did considerable damage to property. On Tuesday last, at Langton, Dorset, during a thunderstorm, a cottage, occupied at the time by a woman and her two daughters, was struck by the lightning. One daughter was killed and the mother was seriously injured. Two rooms were completely wrecked, windows, glasses, &c., being utterly smashed.

Electricity in Australian Sugar Mills.—An electrical plant has just been installed in a sugar mill at Bingera (Queensland) by Messrs. Trackson Brothers, of Brisbane. It consists of a 10-kilowatt Firth dynamo, giving 110 volts when running at 900 revolutions, and furnishing current for 70 20-c.p. lamps and 5 250-c.p. Sunbeam lamps. It is also intended to put down a power plant (the first it is said in Australia) using 3 to 6-H.P. motors. An overhead tramway is also projected, which is estimated will prove to be 30 to 40 per cent. cheaper than horse traction.

Antimony in Electrolytic Copper.—Herr W. Hampe states in the *Chemiker Zeitung* that all the specimens of electrolytic copper which he has examined contained a small proportion of antimony ranging from 0·007 to 0·02 per cent. The precipitation of antimony from the copper ore might be checked if the sulphuric acid were not used for so long a time, and thus did not become so highly charged with impurities, but except for laboratory purposes the extra expense involved in the increased consumption of acid would not be proportionate to the advantages gained by the elimination of the antimony.

The Niagara Falls Scheme.—The *Engineering and Mining Journal* of New York states that the Niagara power tunnel will be completed before October 1st, and that it is probable water will be let into it by that date. The other work is progressing rapidly. On August 20th a meeting of the officers and engineers of the Cataract Construction Company was held in New York, and it was expected that Prof. Forbes and Prof. Unwin would be present. The particular business considered was the development of power on the Canadian side and the transmission of power to Buffalo.

Copper.—According to the statement of Messrs. Henry R. Merton and Co., the stocks of copper in England and France and afloat thereto from Chili and Australia, amounted on the 15th instant to 61,831 tons, comparing with 59,738 tons at the end of July, 56,604 tons at the end of June, and 53,965 tons at the end of May. The total supplies for the first half of the current month are put down at 5,521 tons, against 6,357 tons in the corresponding period last month, while the deliveries have fallen from 4,057 tons to 3,428 tons, and the price of bars which stood at £46. 7s. 6d. per ton at the end of May, has declined to but slightly over £44 per ton.

Electric Motors in a Newspaper Office.—We have received a copy of the *Birmingham Daily Gazette*, which has been printed, cut and folded by the aid of electricity. Messrs. Fowler, Lancaster and Co. have put down a complete plant of electric motors for driving two large printing, cutting, and folding machines for producing papers up to 20,000 each per hour. The current is supplied from the mains of the Birmingham Electric Supply Company, and the runs have been most satisfactory. Electricity will be used entirely from now. The proprietors are most satisfied with the adoption of the new power, especially owing to the convenience of its being available at any moment. We believe that the *Birmingham Daily Gazette* is the first daily paper to be so produced.

Lightning Injuries.—We recorded on p. 150 of our issue of June 12, 1891, that a company of soldiers at drill in an open plain near Berlin had been struck by lightning, and that a large number of them had been more or less injured. Dr. Nicolai has lately published in the German *Military Medical Gazette* the outcome of his prolonged investigation of the case. He comes to the same conclusions as many other medical authorities, inasmuch as he holds that the injuries received on this occasion show that, apart from mechanical and calorific effects, life is most endangered by injury to the circulatory system. The peculiar arborescent figures so generally present on the skin of unfortunate individuals struck by lightning are, according to Dr. Nicolai, mainly due to obstructions in, and consequent tumefactions of, the blood vessels. Another fact brought into prominence on this occasion is the marked directional influence of metallic projections such as are frequently met with on the accoutrements and clothing of soldiers.

The Institution of Civil Engineers.—The Council of this Institution invites original communications during the Session 1892-93 on various subjects. The list published is to be taken merely as suggestive, and not in any sense as exhaustive. The following are the electrical papers suggested:—The Cost of Working Electrical Tramways, taking account of interest on capital, and of a sinking fund for depreciation.—The Most Suitable Form of Electric Light Mains, having regard to durability, economy of conducting-material, and facility for making and laying house-connections.—The Risks of Electric Lighting to Life and Property, with the means to be taken to prevent or lessen them.—The Continuous Running of Steam and other Engines, with Details of Construction.—The best Arrangement of Engine for any given Electric Light Station.—Electrical Motors for (*a*) Inland Navigation; (*b*) Ocean Vessels.—The Electro-deposition of Copper.—On the Application of Water Power and its Transmission to a Distance by Electricity.—The Design of Electric Locomotives.—The Practical Working of Multiphase Alternating-Current Motors.

An Electric Locomotive for Mining Purposes.—An electric mining locomotive has recently been made by the General Electric Power and Traction Company, and is part of a large installation supplied to the Greenside Mining Company, Cumberland. The road on which the locomotive must run being in some places as narrow as 32in., the gauge of rails being 22in., it was found impossible to place the motor across the frame, so its shaft was arranged parallel to the rails. Three reductions are employed, one necessarily being through bevel gearing. The whole framework of the machine is hinged from the driving axle, which is made exceptionally strong for the purpose, the weight on the other wheels being taken through strong spiral springs on the top of gun metal axle brasses. The motor is series wound for a difference of potential of 200 volts, and develops 15 brake H.P. at 1,000 revolutions per minute. The length of the road is 1,200 yards, and the current is collected from two bare copper wires carried on insulators overhead. The E.M.F. is reduced from 500 volts to 200 volts by means of a motor transformer placed at one end of the line. Water is the prime source of power.

Exports of Telegraphic Apparatus.—The Board of Trade Returns for July were disappointing, showing a combined decrease in the exports of nearly £2,500,000, of which nearly £600,000 was under the head of metals and articles manufactured therefrom. The figures relating to the exports of telegraphic wire and of apparatus connected therewith, were also disappointing. The monthly figures frequently vary considerably. For instance, the total value of the exports in March was less than £19,000, whereas in the following month the exports were valued at over £447,000. This great divergence is naturally due to the special character of the trade, which involves at times very heavy shipments in connection with the

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execution of large contracts. The July exports, however, were poor, as showing a very small total following a very small total in June. The aggregate exports for the seven months to date are the smallest of the past three years. The following is a comparative statement of the exports for the first half of the past three years, and for July :—

	1890.	1891.	1892.
January to June	£721,712	£984,530	£675,835
July	56,575	150,754	25,906
Seven months	£778,287	£1,135,284	£701,741

The Chicago Exhibition.—The following Reuter's telegram, dated Chicago, August 22nd, is interesting :—

Although the appropriation made by Congress for the World's Fair was reduced during the debate in the House of Representatives from $5,000,000 to half that sum, the result will, it is believed, be extremely satisfactory to the managers of the Exhibition. The money was granted in the form of five million special souvenir silver coins of the weight, fineness, and value of the regular silver half dollars in current use. As soon as it became known that the souvenir coins were to be issued to the Fair officials from the United States Mint at Philadelphia, there was an immediate demand for them from all parts of the country. It at once became apparent that the coins could be disposed of by the Exposition at a large premium. The editor of a leading New York newspaper offered 100 per cent. premium for 10,000 coins. Merchants and bankers made similar offers, and during the five days succeeding the passing of the Bill tenders were received for 600,000 of the coins at 100 per cent. premium. A syndicate of bankers in the West offered to take the entire issue at 60 per cent. premium. High offers have also been made for the first souvenir coin struck at the mint. A Chicago newspaper started the bidding at £25, but several wealthy men in Chicago have expressed their intention of securing this coin if it cost £200. It is probable that the coin will be sold at public auction in Chicago, a certificate from the Director of the Mint going with it to guarantee that it is the only genuine first souvenir coin. It is probable that all the coins will be sold by the World's Fair management at 100 per cent. premium, and that the Exposition will thus double the appropriation.

The Thermodynamic Value of Town Refuse.—At the present moment, when the employment of the heat produced by the destruction of town refuse for generating steam for electric lighting purposes is before the scientific world, the following extract from a paper read before the Liverpool Engineering Society, by the City Engineer of Liverpool, Mr. Percy Boulnois, may be usefully reproduced. Mr. Boulnois stated that he had received some valuable information from Mr. B. H. Thwaite, on the subject of the thermal value of house refuse, from which the following was abstracted :—"The thermal value of the organic matter has been rigidly tested by the calorimeter; and the net value available for external thermodynamic work may be expressed by the formula $Y = \left(\frac{X \times 2 \times 80}{20}\right) \times 1{\cdot}25$, where Y represents the net available thermal value for motive power purposes; and X represents the corresponding value of coal. For instance : two pounds of coal is required for providing the motive power equivalent to one brake-horse power per hour; the amount of refuse that would be required to effect the same dynamic effect would be $\frac{2 \times 2 \times 80}{20} \times 1{\cdot}25 = 20$lb., or ten times the weight of coal required to do the same work. The factor 1·25 is arbitrarily fixed to represent the internal work of evaporation and self-destruction. The proportion of water in organic vegetable matter may vary from 10 per cent. to 90 per cent."

A Polarisation Experiment.—At a recent meeting of the Physical Society of Berlin, Herr Arons described the following experiment on electrolytic polarisation. If we divide an electrolytic vessel with platinum electrodes and acidulated water solution by a partition of some precious metal, such as gold, silver, or platinum, a diminution of current is usually observed; and the metallic partition will be hydrogen polarised on one surface and oxygen polarised on the other. Herr Arons experimented with a view to seeing whether he could obtain a thin enough partition for the two polarisations to annul one another. He employed for this purpose an electrolytic vessel 22cms. long by 5 broad and 8 high, divided in the middle by a sheet of glass pierced by a hole 1·5cm. in diameter. When the sheet of glass with an unobstructed opening was replaced by one which had the opening covered by a piece of platinum foil 0·1mm. thick, the deflection of the galvanometer was diminished, and there was a violent ebullition of gas. Gold and silver leaf partitions caused no disturbance. By altering the resistance out of the galvanometer circuit its deflection was in each experiment brought back to its original value. The following figures give the resistance which it was found necessary to take out of circuit in each case :—Solid Pt plates, 19 ohms; Pt plate pierced with a hole 3mm. in diameter, 5 ohms; Ag and Au (leaf), 0 ohm; four layers of Au leaf superposed 0·25 ohm.

The Absorption of Radiant Heat.—In the *American Journal of Science* for June Mr. C. C. Hutchins has a Note on the "Absorption of Radiant Heat by Alum." It seems, he says, to be the generally accepted opinion that a solution of alum acts as a particularly efficient absorber of rays of great wave length. Whence this idea in regard to the effect of alum solution arose it is difficult to say. Melloni's table, as far as it goes, shows that bodies in solution raise slightly the percentage of transmitted rays above that which passes through pure water. Mr. Hutchins prepared a saturated solution of potash alum in distilled water, and placed it in a cell 0·6cm. thick. The sides of the cell were quartz plates 0·15cm. thick. The heat-measuring apparatus was used to determine the transmission of the rays from a naked gas jet through this cell. The mean of 10 galvanometer readings was 201 divisions. The cell was then filled with pure water, and the mean of ten readings found to be 196 divisions, showing, if anything, that water is a slightly better absorber than alum solution. When two hundred ohms resistance were added in the galvanometer circuit, the deflection produced by the unobstructed gas jet was 240 div. Through the water cell it was 21·5 div. and the per cent. transmitted was 8·9. When a sheet of plate glass 0·7cm. thick was interposed the deflection was 86 div. and the per cent. transmitted was 35·8. A crystal of alum was then found from which a nearly flawless plate was cut. The plate was given a perfect polish on both sides. The plate was 0·37cm. thick, and the deflection of the galvanometer by the gas jet through the plate was 23·4 div., and the per cent. transmitted 9·7. Hence it appears that a solution of alum is no better absorber than is water; and furthermore, that it would hardly pay to use plates of transparent alum, even if they were to be had.

Spanish Telegraph Reforms.—Stimulated possibly by the recent serious strike of telegraph *employés*, the Spanish Director-General of Communications is drawing up a new scheme for the entire re-organisation of the Postal and Telegraph Service, and the various telegraph and technical papers in Spain are actively discussing the proposed reforms. These are, for the most part, of a technical character, and of little interest outside the *personnel* of the Spanish telegraph service. One subject, however, has been brought forward of more general interest, namely, the idea of a system of military telegraphic communication. It has been recognised that, from a military point of view, the Government might be placed in a very serious position at a critical moment in the event of an interruption of communications such as that which the trading community recently had to put up with. It is argued that the question of military telegraphs has become urgent. The Madrid *Dia* is of opinion that the Minister of War should immediately take the subject up with a view to placing the capital of the Kingdom in communication with the principal interior and frontier stations. Our Madrid contemporary considers that the Government might make use, to begin with, of the general telegraphic system, and also avail itself of the railway telegraphs, if only as a temporary measure, until the fuller scheme in all its extensions might be thoroughly carried out.——According to latest advices the Queen Regent of Spain has signed at San Sebastian a Royal decree by which the fusion of the postal and telegraph services of Spain, as established by the former Director-General Señor Don Xavier Los Arcos, is cancelled, and all the rights and privileges of the telegraph department re-established. A certain number of the oldest telegraph officials have been pensioned, and this has enabled the Minister of the Interior to promote a large number of younger men to higher positions. Forty-five inspectors of lines have been appointed, and, generally speaking, steps have been taken by the new Director-General, Señor Don Federico Arrazola, to improve the telegraph service in Spain. The telegraph corps have thus gained all the points they fought for.

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A NATIONAL PHYSICAL LABORATORY.

Great Britain has certainly no need to boast of her supremacy in science, if, at a time of so much scientific activity on all hands, she allows neighbouring nations to take giant strides in the organisation of scientific research and in the establishment of bureaus of scientific measurement, without making at least the attempt to possess herself of similar advantages. It is true that the Royal Observatory of Greenwich has for long done standard scientific work for the conjoint sciences of navigation and astronomy; and that, more recently, the Kew Observatory has been modestly doing the same kind of work for the science of meteorology. Further, the Board of Trade has lately set up a tiny laboratory for the testing of electric supply meters. Yet we seem to be as far removed as ever from the creation of a proper National Physical Laboratory. Such an institution as this, devoted to the double end of organised research and the application of research to the production and verification of standard instruments, would undoubtedly prove of enormous benefit. Just as the existence of Greenwich Observatory has reacted upon the trade of chronometer making (not to speak of other scientific trades allied with navigation and astronomy) by furnishing a test of merit, stimulating rival makers toward the attainment of perfection, so the establishment of a National Physical Laboratory would exercise an equally beneficial, and even more widely-reaching influence upon the various scientific industries that have been growing up in recent years. Should any one doubt this proposition let him learn from the four years' history of the Berlin Reichsanstalt what such an establishment, under the direction of von Helmholtz, has been able to do for Germany. Let him consider what is the significance of the single fact that to that establishment no fewer than 20,000 thermometers are now sent every year to be verified and certificated. Let him read in our pages the account of the researches therein made on alloys suitable for electric resistances, on glass of kinds suitable for scientific purposes, on the proper methods of hardening and tempering steel, and on numerous other practical problems of enormous industrial importance. Then let him ask himself why is it, how is it, that we in England have no such establishment to benefit our industries at home? Why is it, and how is it, that we leave scientific research to the chance leisure of the overburdened teacher or to the tender mercies of the wealthy amateur? Why is it and how is it that a great department of Government, to which is entrusted the spending of millions of money for the purposes of science and art, spends that money almost exclusively on the most elementary sort of teaching of the uninstructed—of the cripples, so to speak—rather than on either the higher teaching of those who have proven themselves to be capable or on the still higher end of research? Research, when conducted by the amateur, tends undoubtedly too often to become amateurish. It is, perhaps, because he has some perception of this that the average Briton is apt to sneer at the advocate of the endowment of research, as one who is only engaged in a research for endowment. But research conducted on an organised plan in a properly equipped building, where research, and nothing but research, is the aim, is a wholly different thing from research carried on by professors during their holidays, or during hours snatched from teaching in a corner of a laboratory organised for instruction rather than for research. It is also a wholly different thing from the, perhaps, too discursive efforts of the wealthy scientific amateur. Our universities, university colleges, and even our technical colleges, have done something from time to time to supply, though but imperfectly, the national want. But there is much which, even if they were better endowed and equipped, they could not do, being organised essentially and primarily for instruction. Let this be fully and fairly recognised once for all. There is work to be done for which an institution is urgently needed that shall not be a teaching institution. No one pretends that Greenwich Observatory is a place for instruction; it was not founded for educational purposes. An observatory is intended for the purpose of making observations—in other words, for astronomical research. What is wanted now for England is a Physical Laboratory, equally relieved from any educational taint or burden, intended as a place for physical observation and equipped as perfectly as modern science will permit for that end.

Prof. Oliver Lodge, who has now for several years stood prominently forward as the champion of such an institution, has shown in some detail in what work it might fitly engage. The preliminary programme of researches which he lays down is enough to tax all the resources of such a laboratory for 20 years to come, quite apart from any such subordinate functions as the standardising of instruments or the custodianship of standards of measurement. If there is urgent need in the scientific and industrial world for researches of such magnitude, there is surely no time to be lost in half measures. Electric science has more to gain than any other in the immediate future by the establishment of a National Research Laboratory. Let the example of Germany spur us on, not to servile imitation, but to the creation of some institution to meet our own needs in our own way. Let every electrician arouse himself, and endeavour to arouse our lethargic politicians into a sense that there are other questions of importance besides even such questions as technical education and the proper way of governing a neighbouring island.

THE BRITISH ASSOCIATION—CONFERENCE ON ELECTRICAL STANDARDS.

The causes which led to the Conference on Electrical Standards at Edinburgh may be briefly stated. Prof. von Helmholtz wrote to Lord Kelvin in May last to express the hope that an absolute uniformity might be obtained in England and Germany with regard to electrical standards adopted as legal in the two countries. Lord Kelvin, with the cordial assent of those members of the British Association Committee to whom he was able to mention the matter, invited Dr. von Helmholtz to Edinburgh to discuss the question involved; and when it was known that he would accept this invitation and bring with him two of his assistants, Dr. Lindeck and Dr. Kahle, invitations were sent to the Bureau International at Paris, and to Prof. Rowland at Baltimore. M. Guilleaume kindly responded to the invitation. Prof. Rowland was unable to come, but the committee had the assistance of Prof. Carhart, who furnished them with valuable information in regard to the Clark cell. A Paper of agenda, which has already appeared in *The Electrician* (July 29, p. 337), was issued by the secretary.

The first subject discussed was the dimensions of a column of mercury which has a resistance of one ohm. Prof. von Helmholtz called special attention to the difficulty of defining the cross-section of a lens column in terms of the square millimetre, because the mass of a cubic centimetre of water is not accurately known in grammes; and the cross-section of the narrow thread has to be found from its mass and its length. He pointed out that this could be met by defining the mass of the column of given length which should have the required resistance, and it was agreed to define this mass in such a way that, assuming the mass of 1 cubic centimetre of water to be 1 gramme, the area of the cross-section should be 1 square millimetre. M. Guilleaume mentioned the results of recent experiments at the Bureau International in the relation of the gramme and the centimetre, and expressed his agreement with Dr. von Helmholtz's suggestion.

The experiments by which the length of the column had been determined were then considered. In this discussion the Committee were aided by the results of an exhaustive criticism of existing measurements by Dr. Dorn, which was communicated by von Helmholtz. This it was understood will be published shortly. In the end it appeared that 106·3 cm. might be taken as the length of the column, with an accuracy of nearly one part in ten thousand. So far, except in regard to the exact manner of defining the cross section, the results agree with resolution No. 4 of the Board of Trade Committee, which runs thus:—"That the resistance offered to an unvarying electric current by a column of mercury of constant cross sectional area of one square millimetre, and of a length of

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106·3 cm. at the temperature of melting, &c., may be adopted as one ohm."

The next question dealt with was the means of practically realising the standard of resistance; and here a distinction must be drawn between a practical unit of resistance and a "legal standard" of resistance. A "legal standard" is some concrete object, a coil of wire for example, which has a definite property, viz., in this case that its electrical resistance under certain conditions is one ohm. Various objections have been raised against making a tube of mercury the "legal standard" of resistance, and accordingly in the Board of Trade Committee Report a material standard constructed in solid metal was adopted. This material standard was to have the same resistance as the column of mercury, but it was to be constructed and verified by comparison with the British Association units. Moreover, if lost, destroyed, or damaged it was to be replaced through the British Association units. Practically, then, these became the units of resistance, and the question of their permanence was one of great importance. The discussion showed that this mode of obtaining the legal standard and checking variations which might occur with time would lead to difficulty, and in the end it was agreed to omit all reference to the B.A. unit in the resolutions. Dr. von Helmholtz described some recent experiments of Dr. Kreschgauer on the resistance of mercury tubes; it also appeared from comparisons made at Cambridge, just previous to the meeting by Dr. Lindeck and Mr. Glazebrook, that coils of wire constructed in Berlin and Cambridge respectively to represent one ohm agreed to about one part in ten thousand; while the mercury tubes constructed by M. Benoit had been shown to agree with those made in Cambridge to about the same degree of accuracy. It was clear, therefore, that a standard in solid metal having the same resistance as the specified column, could be made with considerable exactness, since such standards made at various places agreed so closely, and it was urged that such a standard could at any future time be recovered with greater certainty than was possible if reliance was placed on a wire coil to which an accident might happen even if it were free from secular change. As a result of the discussion the following resolutions were adopted :—

1. That the resistance of a specific column of mercury be adopted as the practical unit of resistance.
2. That 14·4521* grammes of mercury in the form of a column of uniform section 106·3cm. in length at 0° C. be the specified column of mercury.
3. That standards in mercury or solid metal having the same resistance as the specified column be made and deposited as standards of resistance for industrial purposes.
4. That such standards be periodically compared with each other, and also that their values be redetermined at intervals in terms of a freshly set up column of mercury.

Dr. von Helmholtz expressed his complete agreement with these resolutions, and explained that they were in accord with the proposals laid by himself and the Curatorium—the consulting committee—of the Reichsanstalt before the German Government; while M. Guilleaume, in welcoming the decisions, expressed the opinion that the French Government would concur in the recommendations.

The Committee then went on to consider the question of the electrolysis of silver. The Secretary read the clause of the Board of Trade report dealing with this, viz., "That an unvarying current, which, when passed through a solution of nitrate of silver in water, in accordance with the specification attached to the report, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of 1 ampere." The terms of the specification were described, and Dr. Kahle gave an account of his repetition of Dr. Schuster's experiments on the effect of the oxygen dissolved in the solution. He has shown also that by making the solution basic the mass of silver deposited is slightly increased. After further discussion Dr. von Helmholtz stated his opinion that the resolution which had been read expressed the result of experiments made up to the present with all the requisite accuracy, it was therefore accepted.

* The value of the specific gravity of mercury at zero is 13·5956. This multiplied by the length 106·3cm. and the nominal area ·01 sq. cm. gives 14·4521 as the mass.

With regard to the Clark cell, Dr. Kahle described his recent investigations. An account of these, together with his remarks on the electrolysis of silver, and Dr. Lindeck's results on resistance coils of magnesium, will, it is hoped, be printed as an appendix to the Report of the Standards Committee. Dr. Kahle has found for the E.M.F. of the cells issued as standards by the Reichsanstalt the value 1·4341 volts at 15deg.; his H-form cells are somewhat lower. The values found by Lord Rayleigh, Prof. Carhart and Mr. Glazebrook respectively are 1·4345, 1·4340 and 1·4342 volts at 15°C. The numbers were confirmed by a comparison between Dr. Kahle's cells and those at the Cavendish Laboratory, made just previous to the meeting by Mr. Glazebrook. It was agreed that the number 1·434 volts at 15deg. might be taken as the E.M.F. of the cell.

The outcome of the Conference has thus been that the desire expressed by Dr. von Helmholtz for uniformity of standards is in a good way to be realised so far as France, Germany, and England are concerned, while the assurances given two years ago at Leeds by Prof. Rowland and Prof. Barker, make it practically certain that the same numbers will be adopted across the Atlantic. Should these hopes be fulfilled, the Edinburgh meeting of the Association will be long remembered as one at which work of the very highest importance to electrical science has been accomplished.

ON A MAGNETIC BALANCE AND ITS PRACTICAL USE.*

BY DR. H. E. J. G. DU BOIS.

In a Paper on "Magnetic Circuits and their Measurement," read to the Frankfort Electrical Congress in 1891,† the principles of a magnetic balance were explained, with which magnetic curves of any material might be readily obtained in absolute measure. It may be theoretically defined as an electromagnetic system of variable configuration, the reluctance of which always naturally tends towards a minimum; its variations however remaining exceedingly small. I now propose to describe the instrument exhibited to the Section.

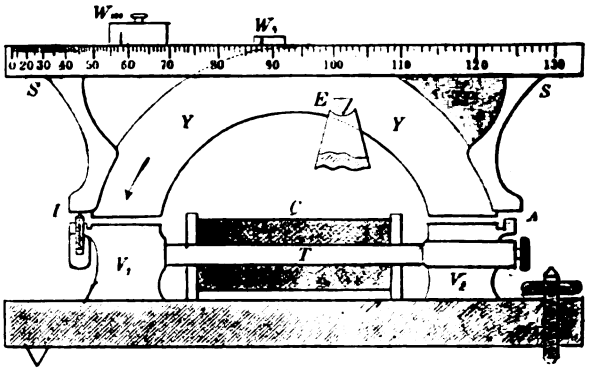

FIG. 1.—Du Bois Magnetic Balance. Diagramatic View

It is the outcome of a year's evolution of constructive detail. By means of a gauge belonging to the instrument, one test-piece T is cut to 15cms. length and 1·128cm. diameter, corresponding to 1 cm.² section; the latter need not necessarily be adhered to, if inconvenient, but has the advantage of obviating all further calculations, as will be seen below. The coil C is 4π cms. long,‡ and wound with 100 turns; therefore, near the middle it gives a field = 10 × current (in amperes). It will carry currents up to 30 amperes, which may be conveniently measured by the usual ampere-meters. The corresponding range of field (0 to 300

* Read before British Association, Section A, Edinburgh, August, 1892.
† *The Electrician*, Vol. XXVII., 1891, p. 634.
‡ Really it is slightly shorter (12·2cms.) to compensate the end effect.

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C.-G.-S.) is all that is wanted in the great majority of cases. The test-piece is supported on two adjustable M-plates, by means of which it may be readily set concentric to the coil, which is then slipped into position, the test-piece being automatically clamped by the plunger in the upright V_2. Fig. 1 (a quarter of the natural size), shows the curved yoke YY of best Swedish iron playing over the stop A and screw I. The latter is enclosed in a cap after calibration, so that the adjustment cannot be interfered with. P is a lead counterweight. Fig. 2 gives a perspective view of the instrument.

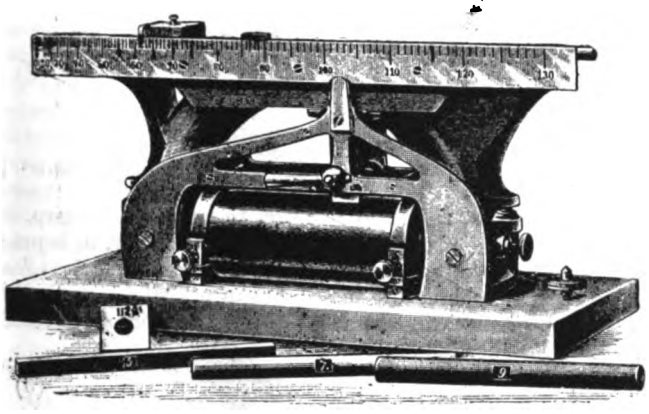

Fig. 2.—Du Bois Magnetic Balance.* Perspective View.

I have made a series of observations to find, experimentally, what function of the magnetisation of the test-piece the resulting moment on the yoke (measured by compensating with the sliding weights) would prove to be. A small secondary was slipped over the middle of T and connected to a ballistic galvanometer. It was found that the resulting moment was accurately proportional to I^2 (or B^2) up to values of $I = 1{,}300$ (or $B = 16{,}000$), with a test-piece of 1 cm.^{2} section; this is all the range that is usually wanted; however, by using a somewhat thinner sample, magnetisations up to 1,700 C. G.-S. may be measured, as the tractive forces really depend upon the flux of induction through the test-piece only.

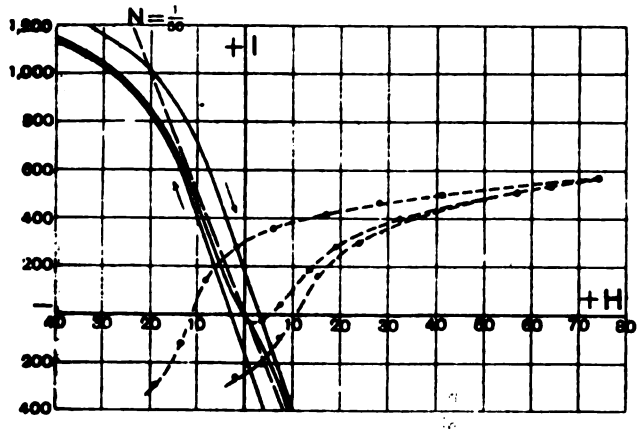

Fig. 3.—No. 7 Ordinary Cast Iron. 25,000 ergs per cm.^{3} Coerc = 11.

After this law had been experimentally established, it was evidently better to introduce a quadratic scale. Along this two mutually independent weights, W_{100} and W_4, slide, of 100 and 4 grammes weight respectively. Accordingly, the scale-readings have only to be multiplied into the square roots of those weights, viz., 10 or 2, in order to obtain the absolute value of I in the sample. The smaller weight is used for the range of $0 < I < 260$; it is then slid back to zero, and measurements continued with the larger weight for $260 < I < 1{,}300$. The instrument does not indicate whether one is to take $+\sqrt{I^2}$ or $-\sqrt{I^2}$; but on plotting the results this becomes at once evident, one of the two points falling entirely outside the smooth curve representing the observations; it is therefore unnecessary to add a special permanently polarised arrangement, with which to detect the direction of magnetisation.

The demagnetising factor N for a cylinder of dimensional ratio (length/diameter) 15 is about 0·12;* it is found in the balance to be reduced to 0·02, corresponding to the threefold ratio 45. This number was found by plotting the curve of a standard sample directly from the balance, and shearing it backwards into coincidence with the normal curve obtained with a ring of the same material. The result was, moreover, arrived at that the usual rectilinear pseudo-axis of ordinates

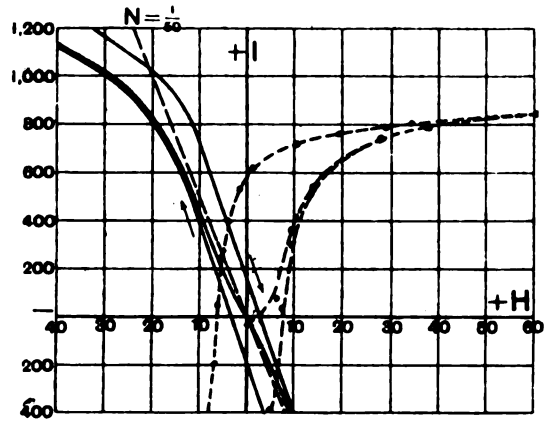

Fig. 4.—No. 6 Malleable Cast Iron 24,600 ergs per cm.^{3} Coerc = 7.

would do well enough up to half the saturation value; but that on the whole it was more accurate to introduce a generalised curvilinear shearing-base. This may be called an instrumental directrix, as it remains characteristic of the instrument when once determined by means of a standard sample; all the corrections due to the uprights V_1 and V_2, the yoke Y Y, the air-spaces with their variable leakages, &c., are combined in it; it is used when ordinary unlooped curves of ascending reversals are being taken. In order also to correct for hysteresis of instrumental parts of the magnetic circuit, it is advisable to introduce two other directrices, the horizontal distance of which

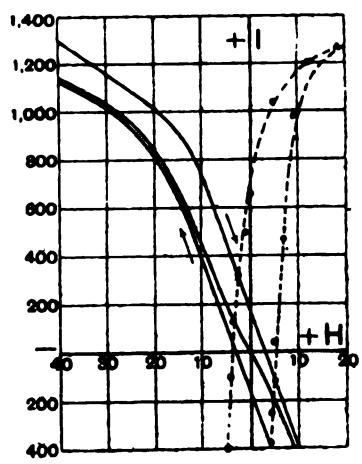

Fig. 5.—No. 9 Iron Wire (Annealed). 20,000 ergs per cm.^{3} Coerc = 4.

measures the coercive force of the apparatus. The left one is used for plotting ascending curves, the right one for the descending branches.

In conclusion, I may offer a few remarks on the practical use of the magnetic balance. The coil is placed in circuit with a reversing key, a good ampere meter, one or two storage cells and rheostats (preferably liquid), so as to admit of easily and gradually reversing, varying and reading the current between 0 and 30 amperes. In the first place, everything should be thoroughly demagnetised by diminishing reversals; accordingly, the yoke is slowly lifted by an arrangement provided for the

* *See* the table in my "Mathematical Theory of Ferro-Magnetism," *Wied. Ann.* XLVI., 1892, p. 498.

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purpose, while the reversing key is being quickly worked; it ought to remain in the lifted position when the instrument is not used, in order to spare the knife edges E. Then the coil is moved towards the observer and the test-piece gradually pulled out, reversing all the time.

The method of taking readings will be sufficiently obvious from the above description; I will only add that on account of magnetic instability the position of the sliding weight is determined, which will just pull the left-hand stop off the screw I; it has been found an unnecessary complication to introduce a secondary bell or telephone circuit as a criterion for the breaking of contact. The observer's ears and fingers afford a readier means, and after some little practice different observers always find exactly the same reading to one or two-tenths of a scale division (corresponding to a unit of magnetisation); this is more than sufficiently accurate.

The tenfold ampere and scale readings (or with the small weight only double the latter) directly give abscissæ and ordinates respectively in C.-G.-S. units. The former are measured from the instrumental directrices as explained above; these are drawn on a transparent card belonging to the instrument, which is laid on the upper left-hand or lower right-hand quadrant of the squared paper, the plotting on which is thereby rendered as simple as when the usual method is followed. If the section of the test piece is not 1cm.^{2}, it has to be measured, and the ordinates have still to be divided by it *after* the above process of plotting.

The dotted curves of Figs. 3, 4, and 5 were obtained with actual samples in the instrument exhibited. The full-drawn lines are the directrices; the middle one for ascending reversals is seen to considerably deviate from the straight line corresponding to $\mathbf{N} = 0{\cdot}02$ as the magnetisation increases beyond 850. From the malleable iron curve (Fig. 4), the first given for this material so far as I am aware, it may be inferred that its magnetisation (for $\mathbf{H} = 65$) is about 50 per cent. greater, and its coercive force as much less than those of ordinary cast iron. Fig. 5 was obtained with a bundle of 124 thin iron wires, presenting a total cross section of 1cm^2.

ON LEAKY MAGNETIC CIRCUITS.*

BY DR. H. E. J. G. DU BOIS.

Ever since the Hopkinsons' researches a great many experiments on magnetic circuits have been made, mostly, however, in the form of measurements on dynamos of various types. Now the results obtained with a particular dynamo may offer a certain degree of interest, especially to its maker; but the utmost care has to be taken in generalising from such data. Quite apart from the consideration that ballistic measurements on dynamos suffer under the undue proportion their time-constant bears to the period of even the slowest ballistic galvanometer, dynamo circuits are not designed for giving interpretable scientific results, but for economy. For all these reasons it seemed to me a useful thing to thoroughly overhaul the whole subject by theorising and experimenting on the simplest conceivable type of magnetic circuit. And though the subject of these circuits has been amply discussed for the last ten years, I venture to hope that its importance may warrant my bringing the first results of this rather lengthy investigation before Section A.

Consider a split-ring magnetised by a uniform peripherical field. Let r_1 be the radius of the central circle, r_2 that of the circular section, d the width of the air-gap. Assuming, then, as a first approximation that the magnetisation is uniform over the whole section of the ring and its direction everywhere peripherical, it may be shown† that

$$\mathbf{N} = \frac{2\,(d + r_2 - \sqrt{d^2 + r^2_2})}{r_1 - \frac{d}{2\pi}}, \quad \ldots \quad (1)$$

where $\mathbf{N}$ is the well-known "demagnetising factor," which determines the amount of shearing over of the magnetic curves.

According to a theorem first given by Kirchhoff, the above state of affairs will strictly occur when the external magnetising field becomes infinite; the direction of the lines of magnetisation is then bound to coincide with that of the applied lines of force. The values of $\mathbf{N}$ actually found must, therefore, approximate to those given by (1) as the field increases.

For less strong fields an exact calculation is impossible; but it may be stated that in this case

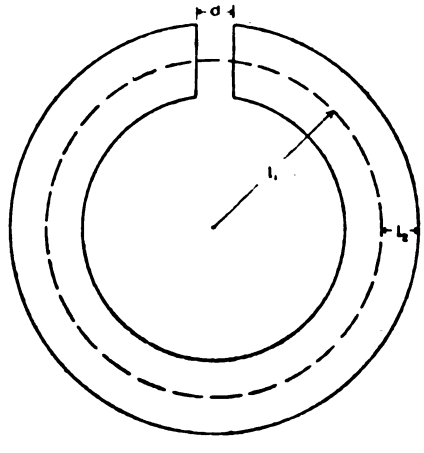
$$\mathbf{N} = \frac{2\,d\,n\left(\frac{d}{r_2}\right)}{r_1 - \frac{d}{2\pi}}, \quad \ldots \quad (2)$$

where the functional notation $n\left(\frac{d}{r_2}\right)$ means a number which is a function only of the ratio of width to radius of air-gap, independently of the rest of the circuit. This number, n, is practically equal to the reciprocal of the "leakage coefficient" as defined by the Hopkinsons.

It may be remarked that both the expressions given converge towards the simple form

$$\mathbf{N} = \frac{2\,d}{r_1}, \quad \ldots \quad (3)$$

when the width of the air-gap diminishes more and more towards zero. In this case the value of n is unity, whereas for wider gaps n becomes a fraction. Moreover, the number n, as well as the factor $\mathbf{N}$, vary somewhat with the magnetisation in a way which it must be left to experiments to determine.



These were carried out under my advice by Mr. H. Lehmann. A ring, about 15cm. mean diameter and 2cm. thick, was turned out of best Swedish plate, and well annealed. It was wound uniformly all round with primary and secondary wire, and its normal curve first taken in the unsplit state. It may be remarked that curves of ascending reversals were taken throughout, the thickness of the iron giving so much time-lag that the step-by-step process would not give correct results. The magnetising field could be pushed to 400 C.-G.-S., the ring being immersed in a trough of iced petroleum.

The ring was now cut, beginning with a very narrow gap of a few tenths of a millimetre width. A small brass disc was fixed in the gap to prevent the iron from yielding to magnetic attraction, and a small secondary wound so as just to enclose the lines of induction crossing the air. Another auxiliary secondary coil could be moved around the ring so as to explore the leakage. The general results may be summarised as follows:—

(1) For the very narrowest gaps the formula (3) holds, as it should.

(2) As the width increases (2) becomes applicable; the values of n found from the throws due to the auxiliary secondaries, when substituted into (2), give numbers for N in good agreement with those found by the "shearing backwards" graphical process.

* Paper read before the British Association in Section A, Edinburgh, August, 1892.

† *See* "Mathematical Theory of Ferro-Magnetism," *Wied. Ann.*, XLVI., 1892, p. 494.

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(3) Both n and N remain practically constant up to values of I about half the "saturation" value, *i.e.*, 850 C.-G.-S.; for higher magnetisations they begin to show an *increase*, N approaching to, but not superseding, the value given by (1), as was theoretically predicted above.

(4) As a rule, the *mean* magnetisation was deduced from the throw due to the principal all-round secondary; this was almost identical with the result given by the auxiliary secondary when diametrically opposite the air gap, and by further exploration with this secondary it was found that an appreciable leakage began to occur only at about one-eighth of the circumference on both sides of the gap.

The numerical values of n within its range of constancy (which is the range of magnetisation mostly worked with) are of general interest because they, or their reciprocals, depend only upon the ratio of width to radius of air-gap, as explained above. Moreover, it will hardly matter much whether the section of the gap be exactly circular, so long as its area be the same; we thus obtain numbers of a certain utility in all questions of design where air-gaps occur. I prefer not to give the actual figures here; they being liable to slight corrections; they will soon be published in full in *Wiedemann's Annalen*, together with the experimental detail.

The result (3) that n finally *increases* with I, I consider to be fully proved by experiment; it corresponds to a final *decrease* of its reciprocal, the leakage coefficient. Now this is in complete disagreement with what is generally accepted as a dogma, viz., that leakage becomes more and more pronounced with larger inductions. This fallacy, as I cannot now help calling it, has generally been explained by the fact that the permeability of iron decreases, and so becomes more equal to that of the surrounding medium. If, then, Ohm's law held there is no doubt but that more leakage would occur. But a true ohmic law does not hold in magnetism; or rather the excellent results obtained by applying it in particular cases do not warrant its generalisation. Its complete failure to predict or explain in the present typical case may be hoped to bring home a little more care in its manipulation to those liable to grow too enthusiastic about magnetomotive force and reluctance.

On the other hand, physical theory is quite competent to explain the final decrease of leakage, which experiment had demonstrated to occur in the split-ring uniformly magnetised. For Kirchhoff's theorem, already alluded to, in connection with the tangent law for the "refraction" of lines of induction at bounding surfaces, clearly shows that those lines will tend to become more and more exactly peripherical as the applied field is being pushed up, thus diminishing the number of lines leaking away into the air.

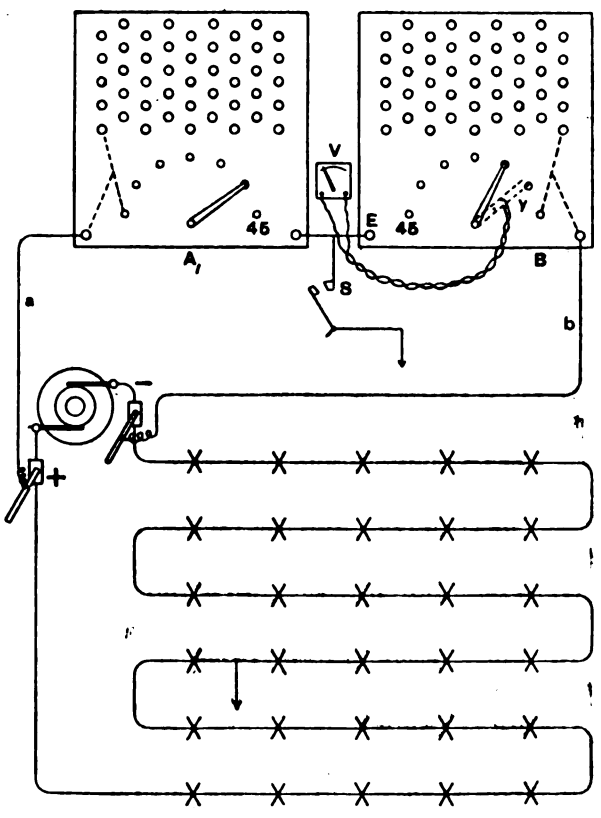
In conclusion, it may be remarked that it is quite possible that leakage may yet increase in particular forms of circuits, where the magnetising field is not uniform all round, *i.e.*, where coils are arranged in some haphazard way, more especially so if there be no coils near the gaps. It has to be borne in mind that on increasing the current in such coils the strong field so applied will finally overpower the self-demagnetising tendencies altogether, and arrange the lines of induction after its own fashion; of course, exactly the reverse happens when weak fields are applied. I intend shortly to investigate this subject a little further by means of a large-sized ring electro-magnet with 12 separate coils, made after my designs by Messrs. Siemens and Halske.

A CENTRAL-STATION METHOD OF LOCATING GROUNDS ON ARC CIRCUITS.*

BY EDGAR E. STARK.

About two years ago the writer made an apparatus utilising the Wheatstone bridge principle, with the object not only to detect a leak on an arc circuit, but to locate it between lamps, irrespective of its resistance. It consists of two banks of 45 120-volt lamps, A and B (*see* figure), connected in series, each bank with a metallic lever sliding over a series of segments connected to the junctions of the lamps in turns. An auxiliary switch y is arranged with two contact blades to touch two adjacent segments of the series, thereby straddling one lamp; the two blades are attached to a Weston voltmeter, V, which can thus read the voltage of each lamp in the series. I use 120-volt lamps on account of the small current they take when run at 50 volts, the current being too small to be noticed when diverted from the arc lamp circuit. These banks or arms, A and B, are connected by a wire, E, which is attached to the switch S with its ground connection. To the other ends of the arms A and B are attached flexible cables, a and b, to connect to the circuit terminals under test.

On installing a set of lamps each arm has to be calibrated. This is done by connecting cables a and b to the + and − ends of a circuit of, say, 80 arc lights; then with all the incandescent lamps in, the levers being on lamp No. 45, the voltage of each lamp is measured by the use of the auxiliary switch y (which is arranged to be unbolted and attached to either board) and the voltmeter. Any lamp that is more than two volts from the average is discarded, and a better one is put in its place. The average voltage is taken, and a lamp selected that equals this average voltage, and this lamp is used hereafter as the standard in computing voltages, &c.



Having the boards thus arranged, after the circuit has been started the cables a and b are attached to the circuit + and − terminals. All the incandescent lamps are cut in; that is, there are 90 lamps in parallel with the outside arc lamp circuit. The ground switch is now opened and closed, and the operator observes if there is any change in the brilliancy of the lamps in the arms A and B. If there is any change when the levers of A and B are in equal and then in largely unequal positions, on the opening and closing, respectively, of the ground switch S, it is indicative of a ground on the arc circuit.

Now comes the "bridge" part of the arrangement. A balance is obtained by altering the number of lamps in arm A or B, as required, so that upon opening and closing switch S there is no change in the voltage of the standard lamp, as indicated by the voltmeter. We have, then, this proportion: The number of lamps on A is to the number of lamps on B as the number of arc lamps on the positive leg of the circuit to the unknown ground is to the number of lamps on the negative leg to the ground. Or A : B :: number of + lamps : number of − lamps. But if we alter A and B so that the voltage of the standard lamp is 50 (or equal to the voltage of the arc lamp on the circuit, if other than 50), then A equals the number of lamps on the positive leg, and B equals the number of lamps on the negative leg to the unknown ground.

The voltmeter will detect a variation of less than ½ volt per lamp. The apparatus will locate between lamps a leak of over 40,000 ohms resistance on an 80-light circuit.

* From the *Electrical Engineer* of New York.

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ELECTRICAL STANDARDS.

The meeting of the British Association at Edinburgh was a convenient opportunity for the consideration of electrical standards, but the position of that body in connection with this subject ought to be clearly understood. The value of the work done by the Association is inversely as the prominence or publicity. There are two functions of the British Association which have little to do with Summer Science and the popular element, but which are of very great importance; one of these is the distribution of annual grants of money to assist research, and the other is the work of the special committees. The Royal Society contributes in a similar way to the advancement of science by grants of money, though of course without any competition or interference. But in the work of special committees, the British Association stands practically alone. It would, indeed, be a pity if there were any competition, for this would be inevitably accompanied by interference. The real work of these committees is generally done by one man. The committees rarely meet to any practical purpose until the annual meeting of the Association, when a report is drawn up for presentation to a section. The easiest way of doing this is to append the names of the committee, including all absentees, to the report which is submitted. This gratifies everybody, and, thanks to the disinterestedness of the true scientific spirit, satisfies the man who has done all the work.

It is to such committee work that we owe the creation of the ohm, the volt, and the weber, in 1863, and the original

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determination of the ohm by MAXWELL and others, from the research carried out at King's College with the assistance of funds granted by the British Association; and nowhere have the initials B.A. been more honourably employed than in the designation of the B.A. unit of resistance. An annual report upon the behaviour of these standards, upon re-determinations and comparisons, and other very important matters, has been a feature of every meeting of the British Association for several years. There has been no attempt or the smallest occasion for an attempt to transfer the responsibility to any other body, and it has been only when proposals have been made to secure the acceptance of the electrical units by other nations that the matter has been discussed by any other body. This was done at a Congress at Paris in 1884, when a number of eminent but self-appointed councillors attempted to create a unit which received the ineffectual and misleading name of the "legal ohm," which served only to create confusion. A similar Congress is threatened at Chicago, but it is to be hoped that before that city becomes filled with Exhibition-mongers and sight-seers, the necessary work will have already been accomplished by men of whom many would probably shun the bustle and excitement and exaggerated delights of a monster bazaar, which seems the last place in the world for important scientific deliberations. The Chicago Congress may adopt the henry, and few will grumble if they approve of megafarads and microboles; they may be induced by M. GUILLEAUME to accept a unit of radiation, and by Mr. PREECE to re-adjust the volt and ampere for the sake of uniformity of indices. The Chicago Congress may be the occasion of the acceptance of the ohm, the volt, and the ampere by the United States Government, if it is thought worth while to delay for a twelvemonth or so what has been already well settled by others.

As we informed our readers some months ago, the time has arrived when scientific men having done all they could in the accurate determination of the chief electrical units, and standards having been constructed by the Board of Trade for their measurement and comparison, the only thing that remained was an Order in Council, by which these standards would receive a legal recognition and value. At this juncture it was very wisely proposed, we believe, by Prof. VON HELMHOLTZ, that some international understanding should be arrived at, and no better opportunity could have presented itself than the meeting of the British Association at Edinburgh. Here it was found by the committee, who really had something to do, that Germany and France were in complete accord with the proposals; and although Prof. ROWLAND, who has been turning his attention of late to that branch of electrical science known as optics, was not present, it was understood that neither opposition nor modification would be pressed from America.

It may be asked, what has the British Association got to do with the Board of Trade and the Privy Council? and the answer is simple. The Board of Trade sought the advice of three bodies, the Royal Society, the Post Office, and the Institution of Electrical Engineers. It was recognised that at the meeting of the British Association a good representation of these three bodies might be expected, and Major CARDEW attended officially, although the committee meeting had no official authority. The adoption of its report, which we publish in another column by the three advising bodies, will be a matter of course; and it may be expected that one of the first duties of the new Government will be the placing of the ohm, the volt and the ampere of QUEEN VICTORIA on the same footing as the yard and the pound, and the other Standards of the Imperial System of Weights and Measures which were made legal and compulsory by the Act of 1824.

GEARING.

BY E. TREMLETT CARTER.

(*Continued from page 428.*)

Rope Gearing.

Where large amounts of power must be transmitted from an engine to one or more machine, it is more economical and efficient to employ ropes rather than leather belting. This form of gearing is used in two ways: the more common practice being to place several separate ropes on V-grooves cut in the rims of cast-iron pulleys, each rope running independently of the others; the alternative method being to wind one continuous length of rope upon all the grooves. In the first of these the risk of breakdown is reduced to a minimum, since the parting of one rope will not cause the others to part, but the ropes are liable to get an irregular distribution of the load and thus to wear unequally. In the second method the parting of the rope arrests the motion of the machinery, which in generating stations may be very serious; but every part of the rope will wear equally, and each span will receive its proper share of the load.

The materials used in rope gearing are tarred or untarred hemp, and cotton. The last of these is the strongest, most flexible and efficient; but it is also the most expensive in prime cost. Hemp is more commonly used, on account of its cheapness. If untarred and dry this material is stronger than if tarred, but is more liable to become fluffy in wear, and has a less frictional grip on the pulley. Untarred ropes will transmit 20 per cent. more power than when tarred, with the same factor of safety. Gearing ropes are usually of three strands without a centre core; the attempts to introduce a core of steel wire having only proved successful in the case of long-distance transmission. The sizes of ropes are usually measured in inches of girth, and vary from 3 to 6½in. The section of material is about 0·9 of the area of the circumscribing circle. Untarred hemp has a breaking tensile strength of about 10,000lbs. per square inch, and an elastic strength (for loads applied for a short time only) of only $\frac{1}{9}$ of this figure. With continuous loads, however, the strands are pulled out on account of the slipping of the fibre, so that a high factor of safety must be taken. To reduce the slacking out which this behaviour of the fibres would cause in rope gearing, a safe working load not exceeding 220lbs. per square inch of section is usually taken. The maximum tension per rope is therefore:—

$$T_2 = \frac{9}{10}\,\frac{\pi d^2}{4} \times 220 = 15{\cdot}76\,.\,g^2,$$

where d is the diameter, and g the girth of the rope in inches.

The coefficient of friction between hemp and cast iron is effectively increased by wedging the rope into a V-groove, provided that the rope does not touch the bottom of the groove. If θ is the angle of the groove (vide *infra*), μ the coefficient of friction between flat surfaces, and μ_0 the coefficient of friction when the rope is wedged into the groove, then—

$$\mu_0 = \mu \text{ co-sec.}\frac{\theta}{2} = 0{\cdot}7 \text{ (in practice).}$$

With this high value of the effective coefficient of friction, and the large angle of embrace which the long-centre distances that are necessary will produce, the ratio of the tight to the slack tension may be very much higher than with belting. Applying the exponential formula given in the section on "Belting," we find that the slipping ratio for an arc of contact of 0·6 of the circumference of the pulley will allow of a practical working ratio of 10. If, therefore, a tight tension of 1,000lbs. exist in the rope, the slack tension need not exceed 100lb., leaving a working difference of tension of 900lb., or 90 per cent. of the tight tension. In belting the working difference of tensions was seen to be only 50 per cent.

Another source of advantage of ropes over belts lies in the much higher velocity at which the former can be run with economy. The greater density of leather causes the detrimental effect of centrifugal force to reduce the most economical velocity of belts to below 3,000ft. per minute; while ropes

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will run economically up to 5,000. Above 5,000ft. per minute the effect of centrifugal action in increasing the tensions on the rope is so considerable that the rope actually transmits less horse-power than at this speed; while above 3,000ft. per minute it is of sufficient importance to render it advisable to make the proper corrections in estimating the horse-power which a given size rope will transmit. The tension due to this cause is equal to the product of the mass of one foot of rope into the square of its velocity in feet per *second*.

$$C = \text{centrifugal action on rope} = \frac{w.v^2}{32.2}.$$

This force must be deducted from the value of the difference of tensions which would occur if there were no such force; thus—

$$T_2 - T_1 = T_2 - \frac{1}{10}T_2 - C = \frac{9}{10}T_2 - C.$$

And since $$H.P. = \frac{(T_2 - T_1)\,V}{33{,}000},$$

we have, $$T_2 = \frac{110{,}000\ H.P.}{3\,V} + \frac{9\,C}{10};$$

and, $$H.P = \frac{V}{33{,}000}\left(\frac{9\,T_2}{10} - C\right).$$

This gives the horse-power that each rope will transmit, allowing for centrifugal action.

Table *of Values of* C *; or the Centrifugal Tension per Rope.*

V in feet per minute.	girth = 3·14. diam = 1.	3·53 $1\frac{1}{8}$	3·93 $1\frac{1}{4}$	4·32 $1\frac{3}{8}$	4·71 $1\frac{1}{2}$	5·50 $1\frac{3}{4}$	6·50 inches. $2\frac{1}{16}$ inches.
3,000	26	32	39	47	57	76	100
3,600	37	45	56	68	82	109	144
4,200	51	62	77	93	111	148	196
4,800	66	80	100	121	145	193	256
5,400	84	102	126	153	184	245	325
6,000	104	127	156	190	227	304	400
6,600	127	152	190	228	274	367	484
7,200	150	181	225	272	327	436	576

From the foregoing data the following table, giving the horse-power which may safely be transmitted through a single rope, has been calculated. Having selected the size of rope that is to be used, and knowing the amount of horse-power which is to be transmitted by all the ropes, the minimum number of ropes can be calculated by simple proportion. It is usual, however, to add one more rope to allow for parting of any one of the set.

Table *giving the Horse Power per Rope, for Untarred Hemp Ropes.*

V in feet per minute.	girth = 3·14 diam. = 1·	3·53 $1\frac{1}{8}$	3·93 $1\frac{1}{4}$	4·32 $1\frac{3}{8}$	4·71 $1\frac{1}{2}$	5·50 $1\frac{3}{4}$	6·50 $2\frac{1}{16}$
3,000	10·7	13·4	16·6	20·3	24·0	32·5	45·0
3,500	11·2	14·2	17·7	21·6	25·5	34·7	48·1
4,000	11·8	14·9	18·5	22·5	26·6	36·2	50·1
4,500	12·1	15·1	18·6	22·7	26·7	36·4	50·4
5,000	11·8	14·9	18·5	22·5	26·6	36·2	50·1
5,500	10·4	12·9	16·0	19·5	23·0	31·2	43·4
6,000	8·4	10·5	13·0	15·9	18·8	25·4	35·4
6,500	7·0	9·0	11·1	13·5	15·9	21·7	30·1
7,000	1·8	2·3	2·8	3·5	4·1	5·5	7·7

The above table, besides being of use in designing rope gear, brings out very clearly the fact that there is a limit to the advantage of running a rope at high speeds; a limiting speed, beyond which a rope will transmit less horse power in proportion as the speed exceeds the limit. In this table, which is here published for the first time, the limit is fixed at 4,500ft. per minute; but the actual value depends on the working stress, decreasing with the amount of stress allowed per square inch section. With 150lb. per square inch, the most economical speed is about 3,500ft. per minute. For tarred ropes a deduction of about 20 per cent. should be made from the figures given in the table.

The size of rope that it will be best to take in any particular case depends on the velocity chosen and the number of revolutions which the pulley will make. For it is not advisable to allow the diameter of the rope to exceed $\frac{1}{50}$th of the pulley diameter, in order that the rope may not be bent round too sharp a curve on the pulley—a practice which would both injure the rope and waste power. Engine pulleys are very frequently 100 to 120 times the diameter of the rope; machine pulleys are occasionally only 35 to 40 times, but are better if made at least 50 times the rope diameter. Where a high velocity ratio between the machine and engine pulleys is required, this is not always practicable with the larger sizes of rope; it is then better to use a greater number of smaller ropes than to risk the injury which the use of large ropes on a small pulley would involve. Ropes must not be used where it is impracticable to have at least 20ft. horizontal centre distance between the pulleys. Very long distances between the pulleys are absolutely necessary to produce the requisite tensions without straining the ropes up to too small a sag. Their tendency to slacken out very rapidly renders this necessary. Ropes will not, therefore, work well on short centres even with jockey pulleys. Very large pulleys need centre distances of from 25 to 30ft. The pulleys are cast in one or two portions, according to the diameter, and the grooves accurately turned on the faces. Great care is necessary that the grooves shall be of the same depth and at the same angle and width, otherwise the ropes will not all run at the same velocity and will be excessively strained on that account. The

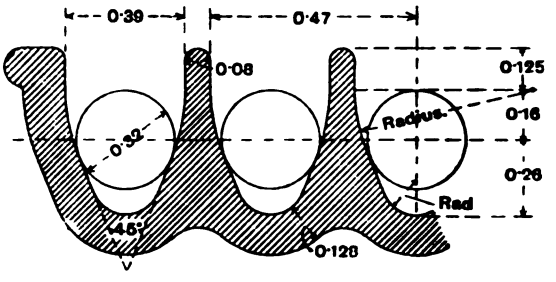

Fig. 4.—Unit = Girth of Rope.

angle of the groove should be from 40deg. to 45deg., and the groove sufficiently narrow at the bottom to prevent the rope touching it at that part. All the ropes should be put on at the same time, care being taken to give them the same amount of sag. If a new rope is put into a set which consists of a lot of old ones, there will be an unequal division of the load, the old ropes getting too large a share and the new one doing hardly any work. Hemp ropes, if designed according to the rules given in this article, will wear well for from five to eight years; and ropes have been known to run for over twelve years without excessive wear. At the end of the time, all the ropes should be renewed; as, leaving on a few that look better than the rest results in trouble and disappointment in running.

The angle of the groove should be sufficiently small to give a good grip on the rope, yet not so steep that the rope is severely crushed between the sides or rubbed on entering or leaving the groove. The proportions of rope grooves are shown in Fig. 4, in which the unit of the dimensions is *g*, the girth of the rope.

In designing rope gearing, it is often necessary to ascertain the space which the ropes will occupy when under any given tension, and this is best obtained by means of a graphic method. In the first place it will be necessary to find the amount of span which the ropes will require in order that a given tension may be produced with a given amount of sag; or, conversely, to find the sag which a given span and tension will produce. The free parts of a suspended rope hang in a curve which approximates to a parabola, and is called a *catenary*. The analysis of this curve is complicated, the general equation being—

$$y = \frac{p}{2}\left(\epsilon^{\frac{x}{p}} + \epsilon^{\frac{x}{p}} - 2\right) = \sqrt{S^2 + p^2} - p,$$

where p is the parameter and s is the length of the curve. The *parameter* is the ratio of the horizontal tension at the

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lowest point of the curve to the weight of unit length of the rope. The writer has devised a graphic method for each of the cases required in practice, which is sufficiently correct for general work if constructed on a large scale. Owing to the fact that the parameter of a hemp rope catenary is so much larger than the span of the curve, it is well not to adopt a scale of less than ½in. to a foot. The method devised by the writer for determining the span when the sag. and tension are known, is shown in Fig. 5. Let B be the point of contact of the rope

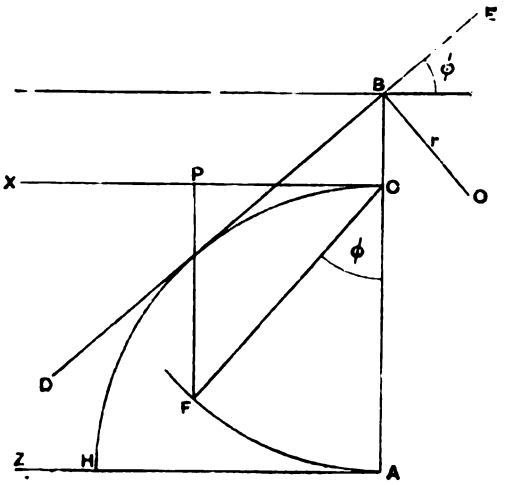

Fig. 5.

with the pulley. From B draw the vertical B A equal to the ratio of the tension to the weight of a foot length of the rope. Mark off B C on B A, equal to the required sag. Then A C is the parameter of the catenary. Draw horizontals C X and A Z. From centre A, with radius A C, draw the arc C H; and from B draw B D at a tangent to this arc. Produce D B to E, then B E is the tangent to the pulley at the point B, and indicates the inclination of the rope at that point. Call ϕ the inclination of the rope to the horizontal at B. Draw B O at right angles to B E and equal to the radius of the pulley. Then O is the centre of the pulley. To find the lowest point on the rope curve, from centre C with radius C A describe the arc A F, making the angle A C F equal to ϕ. From F draw F P normal to C X. Then P is the lowest point on the curve. If the two supports are at the same level, the distance P C is equal to half

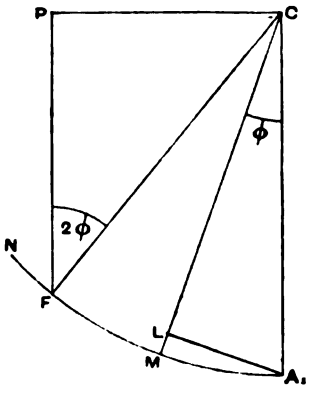

Fig. 6.

the free span; but, if they are at different levels, the operation must be repeated for the other side, or the left hand half plotted from the already determined right hand half by continuing it backwards. (*See* Fig. 7).

In the converse case, in which it is required to find the sag., the tension and span being known, the graphic method is shown in Fig. 6. Draw the horizontal line P C equal to the entire free span; and from C draw C A at right angles to P C, equal to the ratio of the tension to the weight of one foot of the rope. From centre C, draw the arc A N; and from P draw P F at right angles to P C, cutting this arc in F. Bisect the arc A F in the point M; and join M C. Then the angle A C M is equal to ϕ. From A draw A L normal to the line C M; then C L is equal to the parameter of the catenary, and L M is equal to the required sag.

It is sometimes necessary to plot the entire curve for each rope, in order to see what space it will occupy and how the two curves will lie in relation to one another. To determine this the tension in each half of the rope should be taken both for when the rope is at rest and for when it is driving. The sag on the top half is greatest when in motion, but on the bottom half it is greatest when at rest. In Fig. 7, the manner of setting out the semi-curve is shown, the *parabola* being taken, as being sufficiently near to the catenary for practical purposes. P is the lowest point on the curve, and B is the point of contact with the pulley. B C is drawn equal to the sag; and P C, equal to the horizontal distance between P and B, is drawn at right angles to B C. The lines P C and B C are divided into an equal number of equal parts at points 1, 2, 3, 4, on P C, and 1′, 2′, 3′, 4′, on B C. Point P is joined to each of the

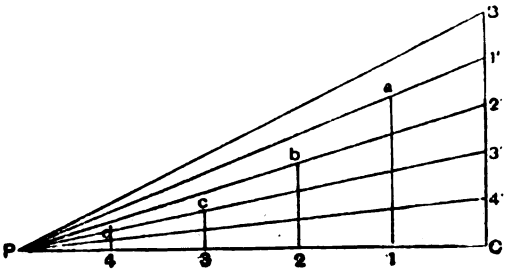

Fig. 7.

latter set of points, as well as to B; and verticals are drawn from the former set of points, cutting the diagonal lines in points *a*, *b*, *c*, *d*, &c., which, together with B and P, are on the required curve. The other half of the curve may be drawn in a similar manner, the method being exactly the same whether the supports are or are not at the same level.

(To be continued.)

THE CONSTANCY OF ELECTRICITY METER CONSTANTS.

Two Ferranti continuous-current meters (Nos. 122 and 127), made in 1885, were fixed in a private residence, and have been in practical use there for seven years. They were both on the same principle as the present form, but were of the earliest type, with cast-iron magnets, the polar face being enamelled, and the ring completing the mercury chamber being plated with nickel.

No. 122 was at work for five years with 20 amperes maximum current, and for two years with 25 amperes, nothing having been done to the interior in the meantime. The constant (*i.e.*, the number of revolutions per Board of Trade unit supplied at 100 volts) was determined by the Kensington Court Company when the meter was first installed to be 60. The following determinations by the same Company were made during the week ending June 25, 1892, the starting current being 0·9 ampere:—

Time.	Current.	Constant.
2 hours	20·5	54·4
2 „	10·21	58·7
3 „	6·58	50·4
		163·5 ÷ 3 = 54·5.

The constant had thus become 9 per cent. low in seven years. The Company, however, state that the measuring instruments used in 1885 show a difference with the present ones, which brings the present constant to within 5 per cent. of its original value.

The Ferranti Company then took the meter, and, without cleaning it, changed the mercury. It was then found to start somewhat earlier, but the constant was not very appreciably affected. The meter was then opened, and it was seen that the recording wheels required cleaning, but were not affected by the mercury. The spindle was not worn either at the top or

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bottom pivot. The pinion was also unworn. The fans were still in a true position on the spindle, and the blades had not been affected by the mercury. The mercury had not escaped or evaporated from the meter, and there was still twice the amount sufficient. It had a slight scum on the top. The jewel at the bottom was dirty, and this retarded the rotation of the meter at low readings. The enamelled faces of the poles and the nickel-plated ring, which together form the mercury chamber, were coated with an amalgam. The number of revolutions made by the meter as it stands at present is 17,820,680.

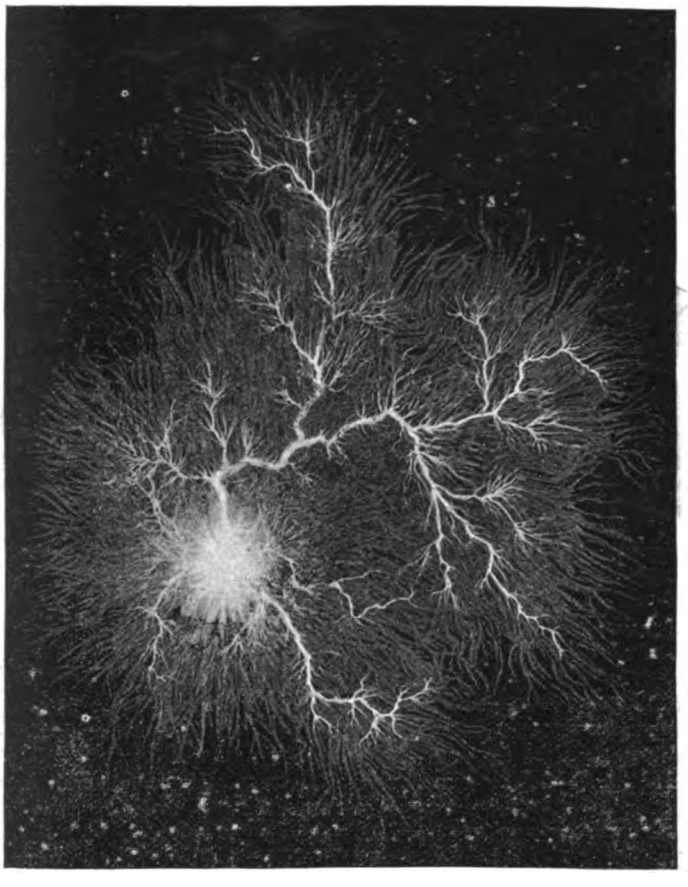
Meter No. 127, in use for seven years, was cleaned in 1890, the original constant as determined by the Kensington Court Company was 48. As again determined during the week ended June 25, 1892, it was as follows :—

Time.	Current.	Constant.
2 hours	21·29	51·7
2 „	10·21	49·0
3 „	6·56	43·0

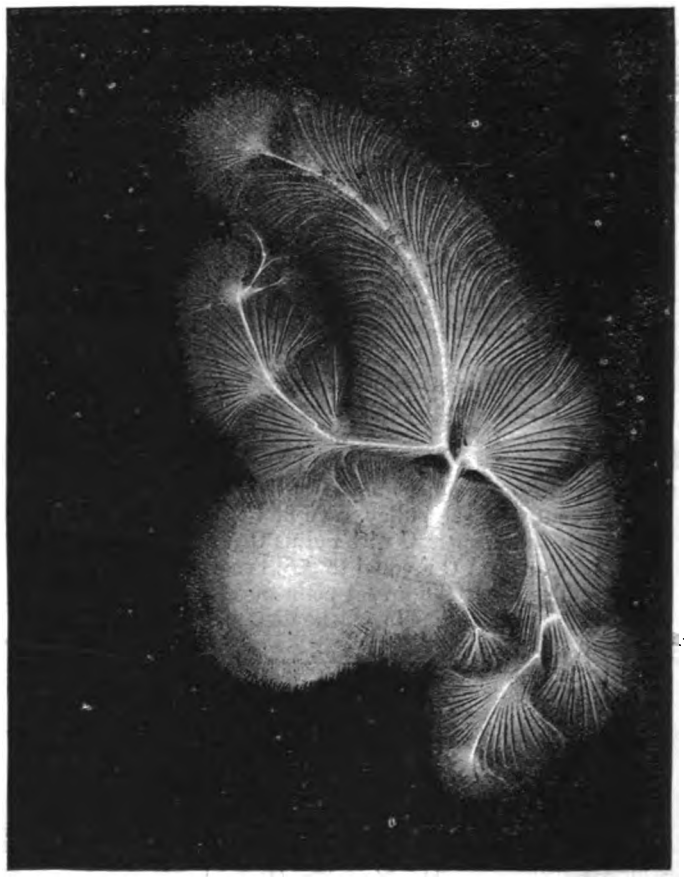
The starting current was 1·45 ampere. The remarks made as to the condition of meter No. 122 on examination apply also to this one.

ELECTRICAL DISCHARGES.

The photographs that we reproduce in the present issue were taken by Mr. A. A. Campbell Swinton without either camera or lens, by merely causing the electric discharge from an induction coil to take place across the sensitive surface of an ordinary photographic dry plate in a perfectly dark room. These photographs were shown by Mr. Swinton at the recent meeting of the British Association in Edinburgh. As was well illustrated in the case of the beautiful experiments at the Crystal Palace, when a plate of glass is placed between the discharging points of a coil or transformer producing a sufficiently high potential, the discharge spreads out over the surface of the glass. With a plain piece of glass there is, of course, a discharge on both sides of it ; but if one side is covered with tinfoil, the discharge will only spread out on the opposite side. If, for the plain glass plate, we substitute a sensitive photographic plate, the back of which has been covered with foil, we have a similar effect. The discharge spreads out on the surface of the sensitive film, and having made a single positive or negative discharge in this way, we have only to develop the plate, in order to produce figures like those illustrated. It may be mentioned that the gelatine and bromide of silver coating that constitutes the sensitive film, does not seem to have any particular effect in modifying the form or character of the discharge ; and the photographs, therefore, are accurate representations of the actual discharges that take place over any insulating surface.



Photograph of a Positive Electrical Discharge



Photograph of a Negative Discharge.

The entirely distinct characters of figure produced by positive and negative discharges respectively will be observed, and it is worthy of note that though the figures invariably differ in form, the general characteristics for positive or for negative, as the case may be, are always the same. It is not easy to suggest any reasonable theory to explain this remarkable difference in the effect of positive and negative discharges. It can, no doubt, be pointed out that, while the negative discharge with its regularly curved lines of flow points to something of the nature of momentum, there is no such evidence in the case of the positive discharge. This, however, does not amount to much, and in the present state of electrical knowledge we must be content to class the phenomenon among the other unexplained differences that are known to exist between what we are pleased to call positive and negative electricity.

Another point to be noticed is the remarkable similarity between the figures and some organic forms, such as some kinds of seaweed in the case of the positive, and feathers or

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branches of palm leaves in the case of the negative. The photographs, in fact, present another curious instance of the remarkable manner in which, under favourable conditions, dead inorganic matter will assume the structural forms that are generally associated with organic life.

THE BRESCIA TELEPHONE EXCHANGE.

It is an unfortunate, but at the same time an indisputable fact that telephone exchanges which have a great number of subscribers, and especially if they are in large towns, work less satisfactorily than smaller exchanges. The universality of this fact shows that such defects cannot simply be attributed to the negligence of the directors, or of the telephone engineers. On examination of the sounds heard in a town telephone, we hear voices in conversation; the clatter of the Morse, which in some instances becomes almost a roar, and a crackling noise, which is caused partly by atmospheric electricity and partly by earth currents. All these disturbances are caused either by induction or leakage from neighbouring wires and earth. It

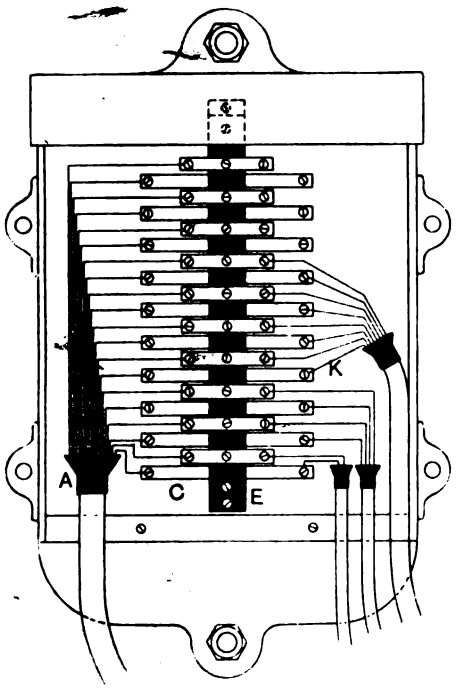

Fig. 1.—Brescia Telephone Exchange. Junction Box for Block of Houses.

is generally supposed that a little care in the insulators, &c., will result in the practical abolition of these troubles; but experience shows that even ebonite has not under certain circumstances sufficient insulating power to prevent telephonic currents leaking from one wire to another when these are fixed upon the same ebonite plate. Another point worth noting is that in telegraphic instruments, where, so to speak, the current works upon dead instruments made of brass and iron, the effects are proportional to the acting forces; but in the telephone, metallic instruments work upon the human ear. Now Prof. Fechner, of Leipzig, and after him Prof. von Helmholtz, have shown that if the intensity of light or sound changes in arithmetical progression, the effect produced on the eye or ear varies logarithmetically. This law, known as the Fechner-Helmholtz psycho physical law, is of the highest importance to the telephone engineer because it shows in what an enormous proportion we must augment the intensity of the vibration in a telephone if we want to double the effect, and, on the other hand, in what enormous proportion we can diminish such intensity without perceptibly diminishing the effect. Now these facts would appear to point to the absolute necessity, not merely of good, but of perfect insulation, in other words to underground conductors, and to the futility of increasing battery and instrumental power.

A few particulars with regard to a small but well thought-out exchange erected on these lines by Dr. A. von Wurstemberger in 1885 at Brescia, an Italian town of some 40,000 inhabitants, may therefore be of some interest. Here Hunning's transmitters of the Hipp pattern *without* induction coils and ordinary Bell receivers have been installed. With regard to the network the general idea consists in laying down the cables (Berthoud-Borel) underground, and in bringing the ends up the walls of the houses to the height of the first floor. Each cable contains from 4 to 20 wires, and terminates in a box, shown in Fig. 1. A is the cable coming from underground, the wires being fixed to terminals C, which are fastened on the ebonite piece E. From the other side of the box we see the cables which go alongside the front of the houses, or block of houses, to the subscribers, so that from the subscribers to the central office the whole line is represented by a double wire highly insulated and covered with lead. Only those subscribers who are at a certain distance out of town are served by an overhead wire on poles starting from the boxes; but as the number of these subscribers is relatively small, and between the boxes and the central exchange the connection is made by cable, induction and leakage are even on those lines of very little importance. The object of the boxes distributed all over the town is to render the underground cable network easy to tap without opening streets or cutting a cable.

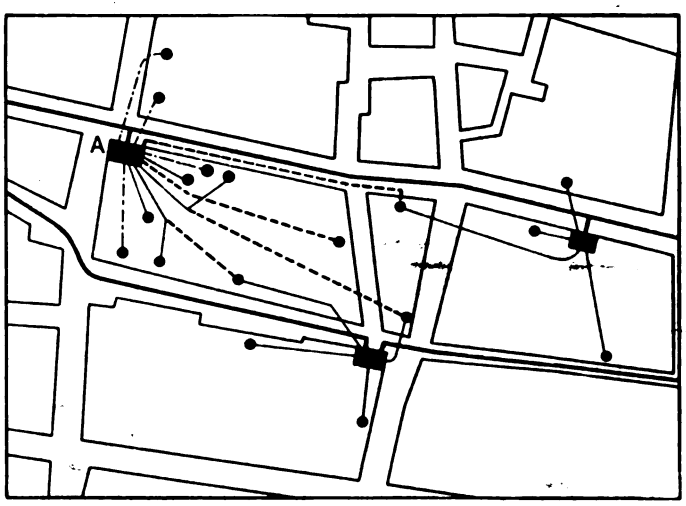

Fig. 2.—Brescia Telephone Exchange. Section of Underground Network.

Wall Box. ——— Main Cable.
● Telephones. – – – – Service Wires.
------- Service Wires disconnected from Box A.
——— Service Wires, run in place of others disconnected.

From Fig. 2 we can see how alterations in the connections can be made without disturbing the streets. Box A was one put up at the beginning; at that time there were only four subscribers to be served who were partly in the same block and partly in the neighbouring blocks. After a short time the twelve remaining wires were taken by new subscribers, and as there was a certain number more to be served new cables had to be laid down. This was not done as might be expected along the old mains, but another line of streets was followed, and boxes were put up on other blocks. Now those subscribers that were some little distance from the first box were connected with the new box, giving thus free lines in the first box to be used as required. The cables taken off the front of the houses were utilised again, and no material was lost.

The laying down of the main at the beginning was managed in such a way that no disturbances in the traffic of the town took place. A little ditch about a foot deep was opened in the day time running alongside the pavement, this little ditch was discontinued at all main crossings of streets. In the evening, generally after 10 p.m., gangs of workmen opened the ditch at the crossings, and by one o'clock at night cable cars began running out the cable into the ditch. As soon as a sufficient number of cables was laid some coal tar and sand were poured over them, and then came tiles, earth and pavement flags fol-

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lowed. The laying down of the cables was carried out between one and six o'clock in the morning, the closing of the main street crossings between 6 and 7:30 a.m., and the filling up the ditches and replacing the pavement was generally terminated at nightfall. In about three to four nights the whole of the cables had been laid down in this way.

As to financial results, the Company has always paid a good dividend (between 4½ and 5 per cent.), and part of the extensions have been paid for out of profits. The cables themselves, as well as the whole plant, showed little deterioration or change in the insulating power, and repairs have only been necessary in a very few instances, where gas or water supply men have dug up a cable by accident and damaged it.

PROPOSED PACIFIC CABLE.

Mr. Sandford Fleming has addressed a letter to Sir John Lubbock, Bart., M.P., the President of the Second Congress of Chambers of Commerce of the Empire, of which we give a summary below. It will be seen that Mr. Fleming advocates the laying of a submarine cable from Canada to the Australasian Colonies under subsidies from the Imperial and Colonial Governments interested. The matter was discussed in *The Electrician* of May 6th, and it was there shown that the subsidies would have to be very large or the working of the cable would be conducted at a loss.

There is a further point which Mr. Fleming does not touch upon. So long as the Australian Government guarantees a portion of the loss due to the low rates on the telegraphic traffic with those colonies, it is not probable that they will very largely add to that loss by fostering a competitive line in addition to paying a subsidy in respect of the proposed Pacific Cable. In addition to this India is interested in the Australian rate, and the Imperial Government may not be inclined to give a subsidy for a cable which will take away a certain amount of revenue from the Indian telegraphs. That a Pacific line would have a certain value for commercial and strategical reasons no one doubts; but a long single stretch of cable such as that could afford no great advantage in time of war. The depth of water which Mr. Fleming thinks would afford it security certainly would not prevent it being cut, and as certainly would add difficulty and delay in repairing it.

The greatest safeguard for submarine telegraphic communication in time of war is to have as many routes as possible, in the hope that they will not all be interrupted, and to have them in such short sections that despatch boats can quickly bridge over the interrupted sections when necessary. Further, if any attempt is to be made to protect cables, it can only be done where they lie along the track of commerce, which would be patrolled by our cruisers. If the navy were to do nothing else it could not prevent a Pacific cable being cut.

Strong exception must be taken to the statement that the soundings prove the existence of a sea floor in the Pacific probably not less favourable for cable laying than that of the Atlantic. It is only necessary to compare the soundings on the two charts to see that this is not the case.

Then, again, Mr. F. N. Gisborne is referred to "as the man who projected and took no small part in establishing the first Atlantic cable," and Canadian newspapers make the same claim. After exercising considerable care to ascertain the facts as to the inception of the idea of a cable across the Atlantic, the truth appears to be that Mr. Gisborne endeavoured to interest the late Mr. Cyrus Field in an attempt to connect Newfoundland and the United States by cable. Mr. Field was not disposed to take up a matter of that kind; but after the interview with Mr. Gisborne, looking at a globe, he asked himself the question, "Why not continue the line to Europe?" This was an idea which fired his enthusiasm, and he at once wrote to Prof. Morse and Lieut. Maury. The latter replied first, stating that when he received Mr. Field's letter he was just closing a report (dated February 22, 1854) to the Secretary of the United States Navy, showing that soundings proved the bed of the Atlantic to be very suitable for a cable to lie on, and referring to what he christened the "cable plateau." Prof. Morse told Mr. Field that as early as August 10, 1843—11 years before Mr. Gisborne met Mr. Field—he had written to the Secretary of the United States Treasury, giving the results of certain experiments made in the harbour of New York, to show the power of communicating electrically at great distances, at the close of which he said: "The practical inference from this law is that a telegraphic communication on the electro-magnetic plan may with certainty be established across the Atlantic Ocean. Startling as this may now seem, I am confident the time will come when this project will be realised."

Now, if honour is to be given where it is due, it seems to us, and we certainly have no prejudice in the matter, that it is to America, and not to Canada, that the inception of ocean telegraphy is due. Mr. Gisborne is certainly entitled to the credit of interesting Mr. Field in submarine telegraphy, and the latter to that of being the chief instrument in attempting the laying of the first and second cables, although the first was unsuccessful and the second only worked four months.

It may also be pointed out that the shortest available route to Australia is from California to New Zealand, and although we should naturally prefer to see the line when laid terminate at Vancouver or Victoria (Canada), it certainly appears probable that the first section of a Pacific cable will be laid from San Francisco to Honolulu, under subsidy from the American Government. Should this be so it will considerably weaken the claim of Canada to be the starting point.

The question of laying a cable across the Pacific has been agitated for 25 years, more than one company having been formed for the purpose; and apparently while leading Canadians are writing papers, making speeches, and getting resolutions passed at Commercial Congresses, America will play the first card.

Mr. Fleming wrote that he did not propose to dwell on the importance and even the necessity of a complete telegraph system as a means of defending our world-wide Empire, quite apart from its commerce. This almost self-evident proposition had been set forth at other times and places. He would consider the subject mainly from its commercial aspects. A large part of the discussions at the Congress had turned upon drawing more closely the links of connection not only between the Mother Country and the outlying parts of the Empire, but also between the various great groups of colonies. The strongest views had been uttered upon this point, and resolutions had been formally presented and unanimously passed, giving expression to the opinion that every step should be taken which would tend to increase the feeling among British subjects in every part of the world that they were one people and that they had common interests in trade and commerce. That the telegraph had already operated towards this end in a very remarkable way was evident to all, that it may do so still more in the future was equally clear. Few questions, therefore, could have higher claims upon the attention of the Chambers of Commerce of the British Empire than those which related to telegraphic communications. The application of electricity to telegraphy had given to the world an entirely new means of communication at once the most sensitive and the most useful that the mind of man could conceive. In no department of human activity was its utility more constantly thrust upon us than in the fields of commerce. Everywhere the opening of trade relations was quickly followed by the construction of telegraph lines; indeed, in new countries, such as Canada and Australia, the telegraph was not seldom the pioneer of settlement and railways. Everywhere the connection by telegraph and cable stimulated and facilitated commercial intercourse. The extraordinary extent of the change thus brought about was illustrated by the fact, that for communication across the Atlantic no less than ten submarine cables were now in constant use instead of the one which first came into continuous use a quarter of a century ago; it was further strikingly illustrated by the rapid growth of telegraphic intercourse with the East and Australasia, necessitating an increase in the number of wires employed. Already more than £1,000 per day were spent on telegraphic communication between the United Kingdom and the Australasian Colonies alone. British shipping, which controlled so large a part of the carrying trade of the world, had come to depend in great measure upon telegraphic advice for its most effective employment. The overwhelming relative interest which British people had in this comparatively modern means of communication was further proved by the fact that out of 125,000 miles of ocean cable now in existence, at least 90,000 were owned by our people and carried on under their management, leaving only about 35,000 miles, or about one-fourth of the whole, for all the other nations of the world. The proportion furnished no bad measure of the preponderance of British commerce. Great, however, as British enterprise had been in the matter of cable construction, the development of the outlying parts of the Empire was constantly making upon it new demands. One great field had been left entirely untouched.

It may almost be taken for granted that as British commerce expanded nothing short of a complete system, bridging all the great oceans, would fully satisfy its wants. For the present the Atlantic was not inadequately provided for by ten cables, while another was now being added to the two laid to South America. The configuration of the Indian Ocean made the various lines which skirted its coasts satisfy the immediate necessities of

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the case. The Pacific alone was not traversed by a single line of wire. That this condition of things presented a serious hindrance to commercial development; that from a strategic point of view it indicated a serious flaw in our national system for the defence of commerce, were positions which appeared capable of conclusive proof.

At the present time the two largest divisions of the Empire, Canada and Australia, though actually separated from each other by only the Pacific Ocean, were telegraphically separated by but little short of the whole circumference of the globe. Both countries had growing interests upon the Pacific; both were manifestly destined to become great powers bordering upon that ocean; and both looked forward to an increased commercial intercourse with each other. Circumstances might easily arise in the near future which would make it of the greatest consequence that these two countries should be prepared to exercise their influence jointly in order that it might be exercised most effectually. Obviously for either closer commercial relations or for joint action, better telegraphic connection was all but an absolute necessity. The cost of sending messages from Canada to Australia was now prohibitive for all practical purposes; with a wire traversing the Pacific it would be reduced to the lowest possible figure, since the line would be fully employed as an alternative route for European messages to and from the South Pacific. Australians should remember, too, that easy and cheap communication with Canada meant the same with the whole continent of America, so closely were the Canadian and the American systems connected with each other.

When he brought this subject before the Colonial Conference of 1887, he proved by arguments and figures which had never yet been refuted, that the cost of sending messages between Great Britain and Australia over the proposed Pacific line would be far cheaper than by any existing route. Since that time the cost of sending such messages had been reduced one-half, and yet the cost per word by the Pacific route as then stated would be little more than one-half of the present reduced rate by Eastern routes. The calculations on which this estimate was based would be found in memoranda submitted to the Conference, and in the discussions thereupon. Any considerable cheapening of telegraphic rates would immediately react upon commercial prosperity and activity.

Turning now to trade defence the subject assumed a new importance. The highest naval authorities were agreed that in time of war the use of the telegraph would furnish one of the most effective means of giving security to the vast commerce of the Empire. Telegraphic orders sent out confidentially by the Admiralty from time to time would indicate to merchant ships the precise course which they should take on both outward and inward voyages. By this means the protecting naval force could be disposed with complete knowledge of the whereabouts of the commerce to be defended, while an enemy would have no such knowledge. It was believed that by making at intervals changes in the routes indicated, greater security could be obtained. To no part of the commerce of the Empire would such a device for protection be so serviceable as to that of Australasia. Without taking into account the new route by way of Canada, which, in emergency, might be used for commercial purposes; if they took into consideration the alternative routes open around Cape Horn and the Cape of Good Hope, and the vast ocean spaces to be traversed, it would be seen that this system might give to Australasian trade an almost complete immunity from attack except in the immediate neighbourhood of European waters, where the strongest force would be available for its defence; merchants and shippers would readily understand that among other advantages there would result an enormous money saving from reduced risks and insurance charges. But the execution of any such plan manifestly depended upon the completeness and security of a national telegraph service around the globe. A glance at a telegraphic map of the world showed that at present we had no such complete and secure service. England had four possible main lines of connection with the East and Australasia. One went by way of Gibraltar, Malta, Egypt, and the Red Sea. Another passing through France, Italy, and Greece, also went on to the Red Sea. A third traversed Germany, Austria, Turkey, Russia, and Persia. A fourth crossed Russia to the Pacific, whence it connected to the South with Chinese and Indian lines. Perhaps the route now completed around Africa should be mentioned as a fifth alternative. But with all these lines it was for national purposes in time of war a fatal defect that they passed through possibly hostile countries, where they would be useless to us, or through shallow seas where the cables could be easily fished up and destroyed. For issuing instructions, such as have been mentioned, to the merchant ships of our Southern Colonies and our Eastern dependencies, not one of these Eastern lines could in time of war be depended upon for a single day. A line across the Pacific, on the other hand, would not only be far removed from the political storm centres of the European continent, but would have two other great advantages—first, it would pass entirely over British soil, and, second, that it would pass chiefly through deep seas where it could only be destroyed with great difficulty. It would complete the circle of communication around the Empire. From a strategic point of view, then, the value of such a line in time of war would be immeasurable. So striking seemed the necessity for its construction that we might fairly argue that even if the line were for a time commercially unprofitable, the Governments of the Mother Land and the Colonies would be fully justified in bearing a portion of the expense, for the sake of the added guarantee of national security which it would give.

The importance attached to the question of a Pacific cable by the Colonial Conference of 1887 led to the following minutes being unanimously assented to and recorded in the proceedings:—

"1st. That the connection recently formed through Canada from the Atlantic to the Pacific by railway and telegraph opens a new alternative line of Imperial communication over the high seas and through British possessions, which promises to be of great value alike in naval, military, commercial, and political aspects.

"2nd. That the connection of Canada with Australia by direct submarine telegraph across the Pacific is a project of high importance to the Empire, and every doubt as to its practicability should, without delay, be set at rest by a thorough and exhaustive survey."

Following up these, and more specific representations of the members of the Conference, the Admiralty was induced to undertake a nautical survey to test the practicability of the route. The survey had been carried on during the intervening years. The soundings were all that could be desired, proving as they did the existence of a sea floor probably not less favourable for cable laying than that of the Atlantic which was used for this purpose. That the results of the survey were satisfactory might be judged from the fact that sounding operations had been closed, and the Admiralty had taken possession of a number of islands in the Pacific for the purpose of establishing mid-ocean stations whenever they might be required. The Canadian Government had, on more than one occasion, indicated its willingness to give substantial support to this scheme of telegraph connection across the Pacific with Asia and Australia. At one time it had arranged for a special deputation to proceed to Australia to confer with the Governments of the various Colonies upon this and kindred subjects, the chief member of the deputation being the present Premier of the Dominion, Sir John Abbott. The delay in sending this deputation was entirely due to the occurrence of political movements in Australia, which seemed to render the time chosen inopportune.

Canadians might fairly claim that they had some right to press the matter of cable extension on the Pacific from a national point of view, since such an extension would be the natural complement of what they have done towards British consolidation. He might be pardoned for pointing out on behalf of Canada that it was in the genuine spirit of British enterprise that she desired to stretch out her arms to Asia and Australia. Had not Canadians been associated from the first with the development of the great modern means of inter-communication? The man was yet alive who projected and took no small part in establishing the first Atlantic cable, and that man, Francis Gisborne, continued to serve the Canadian Government as superintendent of telegraphs. While he pointed with some pride to what had been done by Canada and by Canadians, they all recognised similar evidences of national spirit and enterprise in Australia and New Zealand, indeed throughout the whole Colonial Empire. If we were to keep the Empire intact, if we were to combine all the parts into a lasting whole, we must connect the units by commerce and by every cord of attachment. To extend, expand, strengthen, consolidate, build up, and maintain the new united Empire we must, without delay, take means to obtain the freest and best intercourse between all the parts.

THE HARTMANN AND BRAUN LEAKAGE INDICATOR.

Messrs. Hartmann and Braun's new form of earth leakage indicator is, in outward appearance (see Fig. 1), like an ordinary voltmeter. With a constant difference of potential between the terminals, the readings can be taken direct in ohms; the readings of an instrument designed for a 2,000-volt circuit ranging from 2 megohms to 0·2 megohm. This range can be diminished to suit users' convenience.

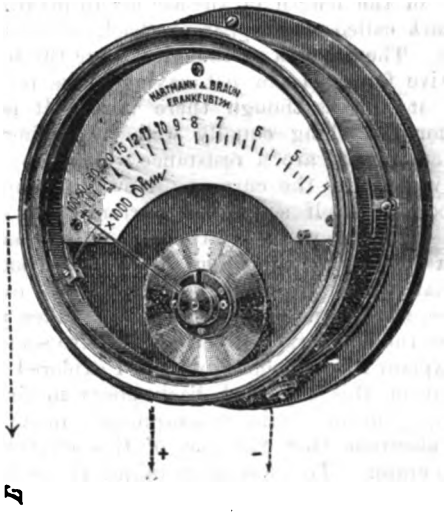

FIG. 1.—Hartmann and Braun Leakage Indicator.

The instrument is connected up as follows:—Terminal E (Fig. 2) is joined to earth. The terminals marked + and − are joined to the leads to be tested. By means of the lever L either lead can be connected to earth through the coil C. If the opposite lead is leaky a current will flow to earth *vid* coil C,

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which will give rise to a deflection, which, with a constant pressure at the instrument terminals, will be proportional to the conductivity of the fault. These indicators may be used either

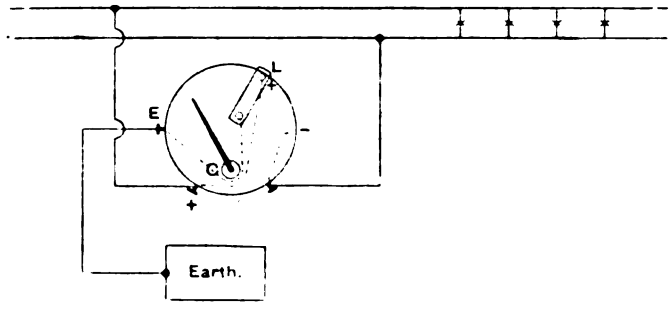

Fig. 2.—Hartmann and Braun Leakage Indicator. Diagram of Connections.

with direct or alternate currents, and all parts are highly insulated, the coil itself being soaked in paraffin wax. Messrs. O. Berend and Co., of 61, Fore-street, E.C., are the English agents for the sale of these instruments.

ON THE PHYSICS OF THE VOLTAIC ARC.*

BY PROF. SILVANUS THOMPSON, F.R.S.

What I have to say relates to the electromotive force of the voltaic arc. If you measure with a voltmeter the difference of potential between the two electrodes of the arc, you find, when the arc is steady, the total voltage so observed is something over 40 volts, and it is known that part of this varies with the length of the arc and the current sent through the arc, and that part is practically independent of either the current or the length. There is a constant part and another part, which varies nearly directly as the length of the arc when the current is constant, and nearly inversely as the current when the length of the arc is constant. A useful approximate formula for the steady arc is $v = a + b\frac{l}{i}$, where a and b are constants, l the length of the arc, and i the current. The constant a varies between 35 and 39 volts; whilst when l is given in millimetres and i in amperes the constant b has values between 8 and 18.

Now, this constant part of the voltage, which is independent of the strength of the current for an invariable length, and independent of the length of the arc for an invariable current, is sometimes called the apparent back electromotive force of the arc. The arc acts as though it were the seat of a back electromotive force. I am not saying there is actually one, only that it acts as though there were. It is possible to account for the thing equally well by saying that there is somewhere in the arc a resistance which proportions itself always inversely to the current. Now, how can any resistance proportion itself so to the current? It can only do so in the following way:—If there is at any one surface of the arc a something equivalent to a transition resistance, then if that varies inversely with the area over which it takes place, and if the area over which it takes place is proportional to the current, then you might have something of the kind to explain this. Some years ago I explored the question of the seat of this supposed back electromotive force, and established, by means of the measurements made with a third moveable electrode, that the seat of this electromotive force was at the crater. This was when taking the ordinary method of producing the arc between two carbon electrodes, an upper and a lower. I explored where the great drop of potential, 35 to 39 volts, occurred. I found that the drop of potential along the arc only amounted to a few volts, and where the great drop took place was at the surface of the positive electrode or crater. This is where most of the work of the arc is done. That being settled as to position, the next question was, what was the physical process going on there which would require such absorption of energy which made this great fall of voltage, and I could only account for it at the time by supposing that the volatilisation of the carbon required it. I was led to this by various reasons, one being Captain Abney's discovery that the surface of the crater is always of an equal intensity; the brilliancy for the same quality of carbon per square centimetre was always the same. I was led by that to think it must be simply a question of volatilisation.

Quite recently, however, Mr. Crookes has made the observation that the flaming discharges produced by alternating electric currents at very high rates of alternation and very high voltage are really endothermic flames of nitrogen and oxygen; in other words, those flaming discharges are simply flames which, instead of giving out heat, absorb heat. Now, in the voltaic arc, as produced in air, something of this kind may occur. There must be a temperature high enough to bring about for the time being the combination of nitrogen and oxygen. We know from Prof. Dewar that such combinations are going on. The question consequently occurred to me whether this had anything to do with the voltage of the arc; and within the last month I have made a number of experiments to put this particular point to the test. A number of experiments were made in my laboratory to test whether the possible combustion of nitrogen and oxygen together had anything to do with the electromotive forces there observed. We did this by surrounding the arc by a glass tube, into which we could introduce a number of gases, say oxygen, nitrogen, carbonic di-oxide, hydrogen, and so forth. Using always short arcs, and waiting until the current was adjusted to 10 amperes and the arc adjusted to the exact length, we found it does not really make one volt difference. The back electromotive force, or whatever it is, is independent of the surrounding atmosphere.

Incidentally we have observed several effects, namely, that when chlorine and carbonic oxide are used as the atmosphere in which to produce the arc, the crater takes a quite different form from that of the usual arc. The carbon is flattened over the end instead of hollowed, and the negative carbon is also a very obtuse cone. Also when the arc is made with hydrocarbon or coal gas around it the crater is formed, but the edges do not burn away as they do when the arc is made in air. Consequently, there is a regular sooty deposit all round, and the arc is formed up inside a sort of cage. When the arc is made in oxygen, both the carbons burn away very fast. Instead of their ordinary consumption there is an extraordinary consumption which burns them down conically a long way. We have also observed in bringing these gases to the outside of the arc it is necessary that they be introduced gently, without violent draughts, because with even a gentle current of gas the voltage is altered. By blowing on an ordinary arc in air the voltage has been made to rise to as much as 75 volts.

The experiments were conducted by Mr. Eustace Thomas, one of the demonstrators, and by Mr. Portheim, one of my students, to both of whom my thanks are given. There still remains much to do in measuring with exactitude the small variations which may be due to endothermic actions.

* Paper read before the British Association, in Section A, Edinburgh, August, 1892.

THE EWING MAGNETIC CURVE-TRACER.

The following is a report of the discussion which arose after Prof. Ewing's description of his Magnetic Curve Tracer, an account of which appeared in our issue of August 12th:—

Dr. JOHN HOPKINSON: Some experiments that my son has been making for me during this spring will, I think, give an answer to one question which Prof. Ewing has put forward, as to whether the curve of cyclic magnetisation is the same when gone through rapidly as when it is gone through slowly. The experiments were done in a perfectly simple and straightforward way, with a transformer made of very fine wire $\frac{1}{100}$in. in diameter, the wire being varnished before being wound. The experiments were performed both with soft iron wires and with hard steel wires. First of all, the curve of cyclic magnetisation was determined when the instrument was used simply as a transformer. It was done by a make and break arrangement, by which the E.M.F. could be measured at-

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any time in the cycle. Then the E.M.F. curve was integrated, and the integral of that curve gave us the induction. The cycle was gone through with great rapidity, about 100 periods per second. The slow period was done in the way Prof. Ewing made use of long ago. The two curves were then compared. We found a difference. When the cycle was gone through slowly, the points lay precisely on the curve all the way down; but they deviated a little inside on the lower part of the curve (*see* Fig. 1). That appeared to be the only difference between the curve of magnetisation when gone through rapidly and when gone through slowly. On the return curve, of course, it was exactly the same thing. That was the case both with soft iron and with hard steel. Of course, when we had thicker wires we at once had the influence of Foucault currents in the wire. With a millimetre in diameter it became very appreciable. When we thinned our wire there were no effects from Foucault currents. Again, when we neglected to varnish the wire we at once saw the same effect.

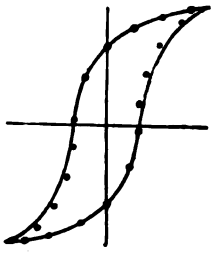

FIG. 1.

A discussion arose in which Lord Kelvin, Dr. Hopkinson, and Prof. Silvanus Thompson took part, with regard to the effect on the magnetic resistance of the transformer circuit of various ways of arranging the core wires, and three diagrams (Figs. 2, 3 and 4) were drawn on the blackboard. Fig. 2 represented a single turn overlapping, and Fig. 3 two turns. Lord Kelvin pointed out that if the wire was coiled as in Fig. 2, the lines of force would have to cross what was practically an air gap of exceedingly small amount, depending on the thickness of the varnish. Dr. Hopkinson thought the effect must be very minute. Prof. Silvanus Thompson suggested that by not bringing the ends round, and joining as shown in Fig. 4, the variations in the curve alluded to by Dr. Hopkinson might be accounted for.

FIG. 2.

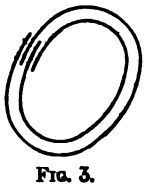

FIG. 3.

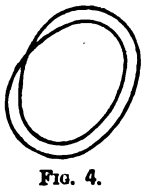

FIG. 4.

Prof. PERRY: When I saw Prof. Ewing's beautiful experiments last night I did hope that it would have cleared up this difficulty, because I understand he has actually got 40 cycles per second, and still got a hysteresis curve something like he showed in his experiments; but I should like to ask Prof. Ewing whether he is quite satisfied that the hysteresis curve is at high frequencies approximately like what it is at low speeds; or does he only expect to find proof by further experiment with much more rigid apparatus and much more rapid cycles?

Prof. EWING: In answer to Prof. Perry's question I am only able to speak positively regarding frequencies up to 20 per second or thereabout. But up to such frequencies as that there is no doubt that the general form of the hysteresis curve remains unchanged. I do not say that there are not changes in detail; it might be a little wide, might have such changes as Dr. Hopkinson spoke of just now; but the general character of it remains unchanged. The peculiar double letter S with sharp corners is certainly there, and the first influence of increase of speed beyond a certain limit, the first obvious effect, is the rounding off of the corners. It is well known, as Dr. Hopkinson has mentioned, that this is one of the effects of eddy currents in the iron itself, and how far this distortion which I have noticed taking place at a speed exceeding 20, is due to eddy currents I am not able to say. I believe from the dimensions of the laminated iron I used last night there might have been some distortion due to this cause. In the other instrument, where the bars are thick, it is not possible to perform even a reasonably good cycle at such a speed as one cycle per second, not, as has been suggested, on account of the mechanical inertia at all, but on account of what we may call the magnetic inertia. It is altogether a magnetic phenomenon. I have had some previous experience of time lag in other experiments, but I was altogether unprepared for the effect in this. Even when we attempt to go through the cycle at the rate of, say, one per second with these thick bars, the curve immediately takes up a form with no sharp corners at all, the area is greatly increased, and the maximum lies much inside of the end. At a little higher speed it becomes practically a sort of inclined ellipse. This cannot be an effect of mechanical inertia at all, as you can easily see by testing for dead-beatness in other ways, or by substituting fine wires with which it is possible to reach a speed of 10 per second or more without distortion. The interesting point is this—that this magnetic sluggishness occurs with thick bars, especially with soft iron in an annealed state, and it occurs, I think, to an extent which it is very difficult to ascribe to the presence of Foucault currents. I am rather inclined to ascribe it to a result I mentioned here two years ago, a genuine magnetic time lag, due to the molecular displacement which is consequent on the magnetisation taking place in the following manner:—Suppose we have a very homogeneous material to deal with, in which the molecules are arranged with great regularity, then those which yield first to the magnetic force will be the outermost ones, for the molecules on the surface are less constrained by neighbours than those inside. The disturbance of them precipitates the remainder into a state of instability, and so we have the process of magnetisation creeping into the interior from the surface. The kind of time lag exhibited in this way can very easily be seen by means of the model magnets I showed last night. If we are dealing with a thick bar, there is a great distance relatively for the magnetic disturbance to travel into the interior from the surface where it begins; but if we are dealing with a very laminated material, then we have ever so many more points subject to the surface conditions, and therefore capable of serving as origins of disturbance, and so the whole mass takes its magnetism much more rapidly than in the case where it lies far away from the surface points. I think the sluggishness which the thick bar shows is due as much to this cause as to the eddy currents.

THE NOMENCLATURE OF ELECTRICAL UNITS.

The following is a report of the discussion on the Nomenclature of Units, which took place at the recent meeting of the British Association in Section A on Tuesday, August 9th:—

After some remarks by M. GUILLEAUME on a proposed unit of radiation and of pressure,

Dr. JOHN HOPKINSON: I think we ought to be exceedingly cautious in the adoption of new names for units and so on, especially when a science is in the state of rapid development in which practical electrical science is at the present time. We have, I think, in some of the proposals of Dr. Lodge to-day a very good illustration of the somewhat premature adoption of particular names for particular purposes, for now he proposes to alter the signification of the terms already adopted. It seems to me, too, that we should be still more cautious in altering the names already fixed. In looking through the proposals of Dr. Lodge, we find first of all he proposes to alter the meaning of the word "farad." He wants to call that which has hitherto been called a microfarad a farad. That, to my mind, is open first of all to the objection that we should always have to refer to the date at which a Paper has been written to know the signification of the term. It is true that in many cases from the context we might ascertain what was intended; but cases might arise in which it would be difficult. That would, to my mind, be a great objection to altering the meaning of a term, even if it be clear that it is desirable to alter it, which in this case I greatly doubt; for, looking to the future, it is quite conceivable that we may be able to manufacture and cheaply manufacture, condensers or quasi-condensers of capacities comparable with a farad under the old acceptation of the term. Is it not possible that we may get liquid condensers or quasi-condensers which will have considerable capacities? We certainly can make such condensers; the only objection to them is that they are wasteful in power. That difficulty may be got over. If it is we shall have condensers of a capacity of one farad, and if Dr. Lodge has altered the signification of the term we shall have megafarads, which will be matters for every-day discussions as micofarads are now. I see Dr. Lodge has dropped his proposals with regard to the coulomb and the watt. With regard to the magnetic circuit, he calls attention to the fact that there are three names used with regard to the coefficient of self-induction, the secohm, the quadrant and the henry. I confess for my own part a great preference for the name quadrant, for that is a name purely and simply for a length. Coefficient of self-induction *is* a length and nothing else but a length; why then should we call it anything else than a length? You may measure it in yards or metres or what unit you please; the actual unit we do use is the quadrant of the earth's parallel longitudes. Then there is another proposal of Dr. Lodge's, from which I dissent. He proposes we should use the weber as the unit of total induction. Well, that to my mind would be quite unobjectionable if the weber in the past had not been used in a totally different signification. Not so long since it was used as the unit of current, and if we give it a new signification, we shall have to know the date at which a Paper was written in order to know the real signification of the term. One would willingly do honour to the name of Weber; at the same time if we are to adopt a name for this unit, which I doubt at the present time, we ought to take some other name. The last point I would like to remark upon is on the proposal made with regard to "mo." Well, there it is, not that I object to the adoption of a name, but this I do feel that it is a very doubtful name to adopt. I think scientific men may go the length possibly of manufacturing mongrel names compounded out of two or three or more languages without doing any great violence to their feelings. They might, no doubt, subject themselves to the hypercriticism of the linguists. But there is a point beyond which we ought not to go, and I think if one imagines the sensitive feelings of the linguistic gentlemen harrowed as they would be harrowed by seeing the words actually turned inside out, one feels we should desist and take some other term for the reciprocal of resistance.

Mr. W. H. PREECE: I am afraid Dr. Hopkinson forgets that the word "mho" is almost historical. It was proposed some years ago by Sir William Thomson to represent the reciprocal of resistance, and it is in frequent use, and there are instruments at the present day known as mhometers. I do not object to the word "mho." What I do object to is Dr. Lodge's way of spelling it. It is a very bad habit to drop our *h*'s.

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"Mho" has a significance, and it may be that it conveys an idea. There is another proposal to which I have no objection, and that is the transference of the term "farad" from the very large unit originally proposed to the smaller one proposed by Dr. Oliver Lodge. It happens, fortunately, that in literature and in papers generally the index ϕ, the Greek letter, is used very much indeed to indicate the unit of capacity, and it matters not whether that ϕ be called a microfarad or a farad. In my experience I have never known a single case of the word "farad" being used. It is infinitely greater than anything in use. It may be that in the dim future Dr. Hopkinson sees the possibility of using these enormous quantities, but that time is not yet. It would be just as easy to call them megafarads as it is to speak of megohms. I think there would be an advantage in converting the term microfarad into farad. Dr. Oliver Lodge has said I spoke favourably of this change. I did so, because it was consequent on another change which is, to my mind, of far greater significance than any other proposal of Dr. Lodge's. It is that the value of the unit of electromotive force should be raised from 10^8 C.-G.-S. to 10^9. Now, if we were to raise the unit of the electromotive force by one more power of 10, we should at once place the practical units that we use most frequently on the same line exactly as the C.-G.-S. absolute system of units. Although I do not now propose it, I shall do so next year. At the Congress we hope to hold at Chicago I shall make it a distinct proposal that the unit of electromotive force shall be increased from the power of 8 to the power of 9. Dr. Lodge has dropped nearly all his more revolutionary proposals. I rather think the time has scarcely come when we can apply to the unit of magnetic field or magneto-motive force any name. Names are of immense consequence when we really know the thing to which we are going to apply them, when we are absolutely decided on the very thing we are going to deal with. We are not quite clear yet on the points of what may be called "gaussage," "weberage," or "lodgage," and a few other things, and we certainly shall have to postpone the final discussion of these matters until we have the results of a Congress, which I hope will have very great results indeed—the Congress next year at Chicago. Therefore I only agree with Dr. Lodge in the proposal that the term farad be applied to the present microfarad. He suggests ampere-hour as a convenient term for quantity. Ampere-hour is one of the most convenient units we have. It has not a name, and it does not want it.

Prof. DU BOIS: I can only say that, as far as I interpret the feeling of Continental physicists, I know that if these names are introduced here they will not be used at all on the Continent.

Dr. LODGE: I am sorry Prof. Du Bois does not agree with the gauss and the weber; I thought the Germans, at any rate, would agree with that.

The PRESIDENT (Prof. Schuster): I am sorry the time is so short, and the number of units so large, that there is only an infinitesimal amount of time for each. I sympathise to a great extent with Mr. Preece's difficulty. Whether it is possible to alter now or not I cannot say—that is a very different question; but the inconvenience of the factor 10 is enormous. The units in which I am specially interested—and I hope they will not be dropped—is the question of introducing some form or other of C.-G.-S. unit of pressure. The fact is certainly remarkable that M. Guilleaume first pointed out that 75 cm. of mercury are, as far as we can tell, exactly 1 megadyne per square centimetre. That is a useful thing to know, and the 75 centimetres deserve some recognition and some name. I think the introduction of the word "atmosphere" would be a great help; but there is not any time to enter into that now.

REPORT OF THE BRITISH ASSOCIATION ELECTRICAL STANDARDS COMMITTEE.

The work of testing resistance coils at the Cavendish Laboratory has been continued. A table of values found for the coils is appended. The committee have ceased issuing standards in terms of the legal ohm of the Paris Congress. As will be seen from the table, most of the coils tested are ohms as defined by the resolutions of the committee, and the Electrical Standards' Committee of the Board of Trade. (*See* B. A. reports, 1890 and 1891.) According to these,

1 B. A. unit = 0·9866 ohms.
1 ohm = 1·01358 B. A. unit.

B. A. Units.

No. of coils.		Resistance in B. A. units.	Temperature.
Warden Box, 79	No. 1*a*	0·99979	17·7°
	„ 1*b*	0·99973	17·7°
	„ 1*c*	0·99954	17·7°
	„ 10*a*	9·9928	17·8°
	„ 10*b*	9·9947	17·8°
	„ 10*c*	9·9941	17·8°
Elliott, 0·230 80		1·00016	14·4°

Of the ohm coils the three first in the table have been tested before (Report 1891) it was thought desirable to reissue the certificates in terms of the new ohm standards. A large number of the other coils were constructed as legal ohms, hence the values of the resistance given in ohms at temperatures of 14deg. or 15deg. are low. The coils in many cases are very nearly legal ohms at the temperature given, while they will be ohms some 8deg. or 10deg. higher.

Ohms.

No. of coils.		Resistance in ohms.	Temperature.
Elliott	259 C.L.C. 206	0·99744	15·5
„	260 „ 207	9·9788	15·6
Nalder	3,059 „ 326	0·99941	14·5
Elliott	271 „ 327	0·99805	15·4
„	272 „ 328	0·99810	15·8
„	273 „ 329	0·99795	15·4
„	276 „ 330	0·99811	15·6
„	274 „ 331	9·9860	17
„	275 „ 332	9·9862	17·1
„	277 „ 333	9·9862	17·1
Nalder	3,260 „ 334	0·99912	14·7
„	3,261 „ 335	9·9970	14·5
„	3,058 „ 336	0·99897	13·9
„	3,265 „ 337	0·99668	13·9
Elliott	284 „ 338	0·99870	12·7
„	285 „ 339	0·99856	12·9
„	286 „ 340	0·99670	12·8
„	287 „ 341	9·9707	12·8
Nalder	3,259 „ 342	0·99879	13·2
„	3,262 „ 343	9·9955	13
Edison-Swan	„ 344	9·9945	14·5
Nalder	3,402 „ 345	0·99971	16·7
„	3,403 „ 346	0·99967	16·5
„	3,404 „ 347	0·99870	16·7
„	3,405 „ 348	0·99960	16·4
„	3,406 „ 349	0·99960	16·3
„	3,564 „ 350	0·99962	16·4
„	3,565 „ 351	0·99957	16·4
„	3,566 „ 352	0·99960	16·5
„	3,567 „ 353	0·99949	16·4
„	3,568 „ 354	0·99961	16·5
„	3,569 „ 355	0·99964	16·5
„	3,558 „ 356	9·9928	15
„	3,557 „ 357	99·902	14
„	3,558 „ 358	999·09	13·8
Edison-Swan	„ 359	0·99994	14·4

In addition to the coils given in the table, four ohm coils, constructed by Messrs. Elliott Bros., for the Board of Trade, were tested very carefully. Some fourteen or fifteen comparisons were made for each coil at temperatures between 9deg. and 18deg., between June, 1891, and January, 1892. The coils were compared directly with the B.A. unit, "Flat," the difference being expressed in terms of the bridge wire; while in another series of observations a coil of resistance, 100 ohms, was put in multiple arc with the ohm standard, and the difference between flat and the combination found; in this case the length of the bridge wire used was small, and the possible error arising from uncertainty as to its exact temperature was avoided; that this error was very small was proved by the fact that the two sets of observations gave practically identical results.

The following are the results:—

Elliott	261 ... 300 ...	$1 - 0{\cdot}000309\ (t - 15{\cdot}35)$
„	262 ... 301 ...	$1 - 0{\cdot}000310\ (t - 15{\cdot}35)$
„	263 ... 302 ...	$1 - 0{\cdot}000300\ (t - 15{\cdot}4)$
„	264 ... 303 ...	$1 - 0\ 000312\ (t - 15{\cdot}4)$

In the case of two of the coils, Nos. 261 and 263, there was one observation for each, which differed from the value given by the above curve by 0·00015 ohms, and this was due to the fact that the ends of the coils had got dirty and needed amalgamation. None of the other errors in the sixty observations exceeded 0·00008 ohm, and there were only eight which were as great as 0·00005. Thus the resistances of these coils are known in terms of the B.A. Standard to a very high degree of accuracy.

During the year Messrs. Elliott Bros. have supplied the committee with two 1-ohm and two 10-ohm standards—the tests of these are in progress; two 100-ohm standards are on order. Messrs. Nalder Bros. are also constructing some standards. The Fleming bridge, belonging to the Association, has been put into thorough repair; the mercury had damaged some of the copper connecting pieces.

The secretary and Mr. Skinner have continued during the year their experiments with Clark cells. These have been communicated to the Royal Society, and the Paper is being printed in the *Phil. Trans.*

They find that the E.M.F. of their standard cell is 1·4342 volts at 15° C., while cells set up by Lord Rayleigh in 1883-1884, Mr. Elder in 1886, Mr. Callendar in 1886, Dr. Muirhead in 1890, Dr. Kahle, of Berlin, Dr. Schuster, Mr. Wilberforce, Mr. Griffiths, and these in 1891 and 1892, agree closely, the variations among them all being very rarely greater than 0·0005 volt.

During the Edinburgh meeting the committee were honoured with the presence of Dr. von Helmholtz, M. Gilleaume, of Paris,

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Prof. Cahart, of the United States, Dr. Lindeck and Dr. Kahle, of the Berlin Reichsanstalt. These gentlemen came by invitation to consider the question of establishing identical electric standards in various countries, and two meetings of the committee were held, at which discussions took place. Major Cardew, of the Board of Trade, was present, and took part in the discussion. Dr. von Helmholtz drew special attention to the need for having a unit of resistance defined in terms of a specified column of mercury, and pointed out that the difficulty arising from the uncertainty of the relation between the centimetre and the gramme might be avoided by defining the mass of mercury column of given length, which has a resistance of 1 ohm. After discussion, the following resolutions were agreed to :—

1. That the resistance of a specified column of mercury be adopted as the practical unit of resistance.

2. That 14·4521 grammes of mercury, in the form of a column of uniform cross section, 106·3cm. in length, at 10°C., be the specified column.

3. That standards in mercury or solid metal having the same resistance as this column, be made and deposited as standards of resistance for industrial purposes.

4. That such standards be periodically compared with each other, and also that their values be redetermined at intervals in terms of a freshly set up mercury column.

It was further agreed that these resolutions should be communicated to the Electrical Standards Committee of the Board of Trade.

With regard to the units of current and of electromotive force, it was agreed that the number of ·001118 should be adopted as the number of grammes of silver deposited per second from a neutral solution of nitrate of silver by a current of 1 ampere, and the value 1·434 as the electromotive force in volts of a Clark cell at 15°C.

Dr. von Helmholtz expressed his full concurrence in these decisions, which are, as he informed the committee, in accord with the recommendations which have already been laid by the Curatorium of the Reichsanstalt, as well as by himself before the German Government.

The committee wish to place on record their thanks to Dr. von Helmholtz and the other visitors for the help they have afforded them in coming to so satisfactory a conclusion.

Dr. Lindeck laid before the committee some information as to the properties of the manganese alloy used at the Reichsanstalt for resistance coils, and it was agreed that it was desirable to obtain copies of the German standards in manganese for further comparison with the standards of the Association. The committee, therefore, recommend that they be reappointed, with the addition of Mr. Geo. Forbes, and with a grant of £25, including an unexpended balance of £10. That Prof. G. Carey Foster be Chairman, and Mr. R. T. Glazebrook, Secretary.

Appendix I.

Information Circulated by the Secretary for the Meeting of the Committee on August 4th, 1892, with Additional Notes.

The report of the Electrical Standards Committee of the Board of Trade is printed in the B.A. Report for 1891. Further information as to the values of the units is given in the B.A. Report for 1890. The following summary may be of use.

The Board of Trade Committee recommended for adoption the values ·9866 and 106·3.

The specfic resistance of mercury in ohms is thus :—

$$\begin{aligned} &\cdot9407 \times 10^{-4} \\ \text{Also 1 Siemens unit} &= \cdot9407 \text{ ohms.} \\ &= \cdot9535 \text{ B.A.U.} \\ \text{1 ohm} &= 1{\cdot}01358 \text{ B.A.U.} \end{aligned}$$

The results found by Lord Rayleigh were originally reduced by the use of the value for the specific resistance of mercury in B.A. units found by him. If, instead, we use the value 0·9535, the mean of the best determinations, there we have for the length of the mercury column having a resistance of 1 ohm, the values 106·27 and 106·31.

At the meeting of the committee M. Guilleaume stated that a correction should be made to M. Wuilleumeier's value, which would raise it to 106·31. This arose from some uncertainty as to the correction required to the resistance of mercury for change of temperature, a question on which M. Guilleaume had been working lately. Taking these corrections and omitting the value found by Prof. Wiedemann in accordance with the criticisms of Prof. Dorn, communicated by Dr. von Helmholtz, we arrive at 106·31 as the mean result.

2.—*The Electrolysis of Silver.*

The following values have been found for the mass of silver deposited from a solution of silver nitrate in one second by a current of 1 ampere :—

I.—*The Value of the Ohm.*

Observer, Date.	Method.	Value of B.A.U. in ohms.	Value of 100 centimetres of mercury in B.A.U.	Value of ohm in centimetres of mercury.
1. Lord Rayleigh, 1882	Rotating coil.....	0·98651	0·95412	106·31
2. „ 1883	Lorenz method.....	0·98677	—	106·27
3. Mascart, 1884	Induced current ...	0·98611	0·95374	106·33
4. Rowland, 1887	Mean of several methods	0·98644	0·95349	106·32
5. Kohlrausch, 1887 ...	Damping of magnets	0·98660	0·95338	106·32
6. Glazebrook, 1882 and 1888.....	Induced currents ...	0·98665	0·95352	105·29
7. Wuilleumeier, 1890.	—	0·98686	0·95355	106·31
8.*Duncan & Wilkes, 1890	Lorenz	0·98634	0·95341	106·34
9.†Jones, 1891	Lorenz	—	—	106·31
	Mean	0·98653	—	106·31
10. Strecker, 1885	(An absolute determination of resistance was not made. The value ·98656 has been used.)	—	0·95334	106·32
11. Hutchinson, 1888 ...		—	0·95352	106·30
12. Salvioni, 1890		—	0·95332	106·33
12.* „		—	0·95354	106·30
		Mean	0·95354	106·31
13. H. F. Weber, 1884...	Induced current ...	Absolute measurements compared with German silver wire coils issued by Siemens or Strecker.		105·37
14. „ „	Rotating coil.....			106·16
15. Roiti, 1884.....	Mean effect of induced current..			105·89
16. Himstedt, 1885	—			105·98
17. Dorn, 1889.....	Damping of a magnet			106·24
18. Wild, 1883.....	Damping of a magnet			106·03
19. Lorenz, 1885	Lorenz method.....			105·93

Mascart, *J. de Physique*, III., 1884 ..... 0·0011156
Rayleigh, *Phil. Trans.*, II., 1884 ..... 0·0011179
Kohlrausch, *Wied. Ann.*, XXVII., 1886 ..... 0·0011183
T. Gray, *Phil. Mag.*, XXII., 1886.....about 0·001118
Potier et Pellat, *J. de Physique*, IX., 1890 ... 0·0011192

Dr. Schuster has shown, *Proc. R. S.*, Vol. I., 1892, that the amount of silver deposited when the voltameter is in a vacuum is about 0·04 per cent. greater than when it is in air.

3.—*Clark's Cells.*

The following values have also been found for the E.M.F. of a Clark's cell at 15°C. They have been reduced from those given in the original Papers on the supposition that 1 B.A.U = 0·9866 ohm, and that the mass of silver deposited per second per ampere is 0·001118 gramme.

Rayleigh, *Phil. Trans.*, II., 1884.....V..... 1·4345 volts.
Carhart..... 1·434 „
Kahle, *Zeitschrift für Instrumentenkunde*, 1892... 1·4341 „
Glazebrook and Skinner, *Proc. R.S.*, LIV., 1892 1·4342 „

A comparison has been made between the standards of the Association and the Berlin standards through a Clark cell and a resistance coil belonging to Dr. Schuster. By the kindness of Dr. von Helmholtz, the secretary hopes to have a direct comparison between the two sets of standards completed before the meeting (*see* Appendix III.).

Appendix II.

On the Values of Certain Standard Resistance Coils.

By R. T. Glazebrook, F.R.S.

In the report of the committee for 1890 it was stated that during the early part of the year small changes had taken place in the values of some of the old B.A. standards which had been subjected to a very low temperature early in that year. These coils have been compared together at intervals since that date, and the following tables will show that at the temperature given there is no indication of any further change. The difference between the coils and the standard coil flat is given in bridge wire divisions. The value of one bridge wire division is about 0·00005.

The first few lines in each table give the values of the differences observed in 1890. These are followed by those of the more recent observations which were taken at a temperature of about 16deg.

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Table I.—*Showing the Differences between the Platinum Silver B.A. Units in 1890 and 1892.*

Date.	Temperature.	Flat—F.	Flat—G.	Flat—H.
May, 1890.....	14·4	−3·5	21·5	18·3
June, 1890	16	−3·2	22·2	17·8
August, 1890 ...	16	−3	22·6	18
July 23, 1892	16	−3 7	21·6	18·4
July 24. 1892.....	16·5	−3·5	22	18·3
July 27, 1892.....	16·2	−3·2	21·6	18·3

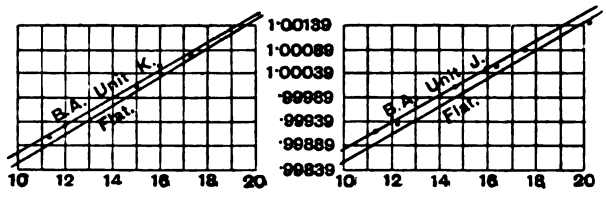
These observations are sufficient to show that there has been no appreciable change in the relative values of these coils.

The observations on the legal ohm standards given in Table II. lead to the same conclusion.

Table II.—*Giving Differences in Bridge Wire Divisions between the Legal Ohm Standards and Flat.*

Date.	Temperature.	C.L.C. 100-Flat.	C.L.C. 100-Flat.
August, 1890	15·7	216·7	206·6
November, 1890	15	217·2	206·7
January, 1891	11·6	216·1	206·8
July 25, 1892	16·3	215·6	205·8
July 27, 1892	16·1	216·0	206·3

In November, 1890, two new coils, marked J and K, were made of platinum-silver wire supplied by Messrs. Elliott Bros. The wires of the coils are wound in a loose spiral inside the case, being secured at intervals by silk threads to an ebonite central stem. They are thus in contact with air only, and there is no paraffin inside the case. It was hoped in this way to secure freedom from the strains set up by changes of temperature in the paraffin which appeared from the results given in the report for 1890 to have some connection with the changes of resistance there described.



Values of the B.A. Units Flat, J and K.

From observations between November 1890, and July 1892.

The vertical divisions are 0·00005 B.A.U. ; the horizontal divisions are 0·1° C. Flat = 1 B.A.U. at 14·8°, temperature coefficient 0·000277 (Fleming's observations, 1876) ; J = 1 B.A.U. at 14° temperature co-efficient 0·000260 ; K = 1 B.A.U. at 14·15° temperature co-efficient 0·000261.

From the six observations for each coil recorded it is clear that there has been no change during the time for which the observations have lasted.

Two observations were made at a much lower temperature, and these would seem to indicate a slightly less temperature coefficient than is shown by the observations between 10deg. and 20deg.

The values of the two new coils in B.A. units between temperatures of 10deg. and 20deg. are given by

$$J = 1 + 0{\cdot}000260\,(t - 14)$$
$$K = 1 + 0{\cdot}000261\,(t - 14{\cdot}15).$$

We may thus conclude that during the past two years there has been no relative change in the values of the platinum silver unit standards of the Association.

Four of these are the original standards made in 1865-67, two others were made by Messrs. Elliott Bros. in 1885, and the last two by the assistant at the Cavendish Laboratory from wire supplied by Messrs. Elliott in 1885.

Appendix III.

On the Values of Certain Standards of Resistance and Electromotive Force sent from Berlin for Comparison with the B. A. Standards.

Towards the end of July Dr. Lindeck, of the Physikalischi Technische Reichsanstalt, at Berlin, brought to Cambridge three resistance coils of nickel manganese copper alloy, in order to compare them with the B.A. standards.

Experiments to determine the value of these coils in terms of the resistance of mercury are in progress at Berlin. When they are completed a comparison of the B.A. units with the mercury standards of the Reichsanstalt will become possible.

A fourth coil, constructed for the Berlin Reichsanstalt by Messrs. Elliott Bros., was also tested. Table I. contains the results.

Table I.

No. of coil.	Date.	Temp.	Value in B.A.U.	Mean value of series.
Wolff 150	July 25	15·5	1·01118*	
	„ 27	17	1 01116	
	„ 25	16·5	1·01119*	1·01118 at 16·7°
	„ 26	16·3	1·01119	
	„ 27	17·1	1·01120	
Wolff 139	July 25	16·5	1·01110*	
	„ 27	16·9	1·01112	
	„ 25	16·5	1·01110*	1·01112 at 16·7°
	„ 26	16·3	1·01114	
	„ 27	17·1	1·01116	
Wolff 147	July 25	16·5	1·01112*	
	„ 27	16·9	1·01112*	
	„ 25	16·5	1·01113*	1·01113 at 16·7°
	„ 26	16·3	1·01112	
	„ 27	17·1	1·01115	
Elliott 250	July 25	17	1·01107*	
	„ 27	17	1·01107*	
	„ 28	17	1·01108	1·01107 at 17°
	„ 29	17	1·01108	

In the experiments marked thus * a considerable length, 200 cm. of the bridge wire, was used. An error of 1° in the temperature of this would produce an error of ·00003 in the result. In reducing the results the temperature of the bridge has been taken at 18°, the value given by a thermometer laid alongside the wire on July 28th. In the other experiments a coil of 100 ohms was put in multiple, as with the Berlin Standard, and the difference of the combination and the B.A. Units was found.

The length of bridge wire was very small, so that an exact knowledge of its temperature was not wanted, while the 100-ohm coil was known with all the necessary accuracy.

Another set of comparisons leading to results which do not differ from the above by more than ·00003 B.A. units were made by Dr. Lindeck, using apparatus he had brought from Berlin ; but a complete discussion of the whole can best be given when the values of the Berlin coils have been found. Dr. Lindeck also brought four Clark cells. Of these two, Nos. 69 and 71, were of the pattern described by Dr. Kahle, *Electrotechnische Zeitschrift*. July 22, 1892. *Zeitschrift für Instrumentenkunde*, Ap., 1892. The mercurous sulphate is enclosed in a porous pot, its zinc dips among the crystals of the zinc sulphate, its end being bent so as to be horizontal. The vertical portion of the zinc is covered with a glass tube, so that the horizontal part alone is effective. The other two, Nos. 12 and 29, were H cells of the pattern described by Lord Rayleigh.

These cells were compared with the Standard at the Cavendish Laboratory with the results shown in Table II., which gives the differences between the four cells and the standard in hundred thousandths of a volt.

Table II.—*Values of Berlin Cell. Standard in ·00001 volt.*

Date.	July 26th.	July 27th.	July 29th.
Temperature.	16·1	15·9	15·9
Cell No. 69	−15	−18	−14
„ „ 71	−11	−15	—
„ „ 29	−36	−35	−36
„ „ 12	−39	−38	−39

On July 29th, cell No. 71 had been taken away.

Dr. Kahle kindly determined the differences between No. 69 and each of the other cells before they left Berlin. Values for these same differences can be obtained from the above Table II.

We thus get Table III.

Table III.—*Differences between Cell 69 and the others sent from Berlin.*

Date and place of observation.	No. 71.	No. 12.	No. 29.
July 19, 1892, Berlin	−2	29	29
„ 20, „	−4	28	25
„ 21, „	−4	25	26
„ 26, „ Cambridge	−4	21	24
„ 27, „	−3	19	20
„ 29, „	—	22	25

Thus the relative values of the cells as found at Cambridge are practically the same as those found at Berlin, while taking

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the E.M.F. of the Cambridge standards as 1·4342 volts at 15deg., that of the Berlin cells with porous pots is 1·43405 and of the Berlin H cells about 1·4338.

The value actually found by Dr. Kahle for the E.M.F. of the porous pot cells is 1·4341 volts, so that the agreement is complete. In all the above it has been assumed that the resistance of 106·30 cm. of mercury is 1 ohm, and that the amount of silver deposited per second by a current of 1 ampere is 0·001118 gramme.

The H form of cell in all cases examined at Berlin has a slightly lower E.M.F. than those with the porous pots, the difference being about 0·0003 volt.

Appendix IV.

On the Standard Condensers of the Association and on Certain Resistance Coils.

By R. T. Glazebrook, F.R.S.

The report of the committee for 1890 contains as an appendix a very full account of the tests on the standard condensers belonging to the Association. It was there stated that while the insulation resistance of No. I. was very high, that of No. II. was not completely satisfactory. No. II. was, therefore, taken to pieces and set up afresh. Its capacity, and also that of No. I, were determined afresh, using the commutator method described in the previous Paper.

The following values were found :—

Condenser No. I.

Date.	Capacity in microfarads.	Mean of each series.
December 23, 1890	0·021059	0·021050
„ „ „	0·021052	
„ „ „	0·021046	
„ 29 „	0·021044	

Condenser No. II.

December 23, 1890	0·021396	0·021395
„ „ „	0·021392	
„ „ „	0·021399	
„ „ „ afternoon	0·021365	0·021389
„ „ „ „	0·021399	
„ „ „ „	0·021403	
„ 29 „	0·021381	0·021390
„ „ „	0·021409	
„ „ „	0·021389	

Mean of the whole..... 0·021391 microfarad.

The different values in each series correspond to different rates of revolution of the commutator.

The value found originally for the capacity of No. 1 was 0·021024 microfarad ; it would appear, therefore, that it may be slowly increasing. The capacity of No. II. has been changed by being taken to pieces, and from 0·022515 to 0·021391.

The two condensers were also compared directly assuming the value of No. I. to be 0·021050, that of No. II. was found to be 0·021390, practically the same value as that given by the commutator.

As a further check on the values a mica condenser was compared with the two in the usual way. The values found were :—

Date.	In terms of I.	In terms of II.
December 29, 1890	0·5017	0·5013
January 1, 1891	0·5013	0·5012

In March, 1892, the insulation of the condensers was tested by the secretary and Mr. A. S. Bowley ; they were both found to lose rather less than one-six hundredth of their charge per 1 minute.

A divided condenser, Elliot No. 144 C.L.C. No. 3 was compared ; the results are interesting as showing the effect on the capacity of the time of charging, and are given in Table III.

The first observation in each case marked as 0″ was made by connecting the galvanometer, and then momentarily making the battery circuit for a very small fraction of a second. The observations on the condenser, 0·2, show that there has been no appreciable change in the relative value of the Standards I. and II. The observations throughout are accurate to about one part in 10,000.

During the process of the work, Mr. Bowley compared several of the resistance boxes of the Association together ; as these are used as standards in many experiments, it will be useful to put the results on record.

Box Elliott 1,253 is a Wheatstone's bridge box of platinum silver in legal ohms, said to be right at 18°. Assuming that the two 1,000-ohm coils of the bridge are equal, and the experiments showed no appreciable difference, the following values were found for certain coils in terms of a nominal 10,000 ohms taken from 1,253.

Table III.

Nominal value.	Time of charging.	Value in terms of I.	Value in terms of II.	Nominal value.	Time of charging.	Value in terms of I.
0·5	0″	0·05022		0·2	0″	0·2003
	5″	0·05072			2′	0·2018
	10″	0·05080			5″	0·2027
					10′	0·2033
0·5	0″	0·05055			20″	0·2039
	5″	0·05106			30′	0·2046
	10″	0·05109				
0·2	0″	0·1988	0·1981	0·5	0″	0·5032
	2″	0·1999	0·2002		2″	0·5058
	5′	0·2007	0·2009		5″	0·5078
	10″	0·2010	0·2013		10″	0·5081
	20″	0·2012			20″	0·5092

Elliott, 1,825.		Nalder, 1,870.	
Nominal value.	Value found.	Nominal value.	Value found.
10,000	10,012	100,000 No. 1	100,042
20,000	20,024	„ No. 2	100,044
30,000	30,034	„ No. 3	100,050
40,000	40,049	„ No. 4	100,034
		„ No. 5	100,042
		„ No. 6	100,042
		„ No. 7	100,052
		„ No. 8	100,032
		„ No. 9	100,047
		„ No. 10	100,052

The temperature of all the coils was about 15·6 C.

Thus the box Elliott, 1,825, is right at about 4deg. below the box 1,253, while the box Nalder, 1,870, is right at about 1·5deg. below 1,253.

DISCUSSION.

The PRESIDENT : It is a rule of the Association not to discuss reports, but in this instance we may, I think, suspend the rule ; and if Prof. von Helmholtz will make one or two remarks upon this point, we shall be very grateful to him.

Prof. VON HELMHOLTZ said that in Germany they were in very much the same situation which had developed itself here in England with regard to electrical measurements. They had taken part with the delegates of England and other European Governments in the Electrical Congress of 1884, when it was resolved that the French Government should bring the decisions of the Congress to the knowledge of the other European Governments, and ask them to make the results arrived at the legal standards in their respective countries. He believed this communication had been made by the French Government ; but, as far as he knew, no Government had taken any steps under the proposal, not even France itself, so that they were in the same position now that they were in before 1884. It was clear now, eight years having elapsed, that a fresh agreement was necessary. The first Electrical Congress at Paris, which was held in connection with the great Electrical Exhibition there, made proposals as good as could be made at that time. There were very few measurements then made, and several of the delegates to the Congress undertook to make new measurements. Their results were brought before a later Congress. This later Congress was official ; the first was only a private one. They then had to choose between numbers which were different to the extent of 1 per cent. ; at least those which seemed to be of sufficient accuracy were still different by 1 per cent., and they therefore had to choose the middle one of them, which was a mercury column, the proposal of Dr. Werner Siemens, one square millimetre in section and 1 metre 6 centimetres in length, at the temperature of the freezing point. They could not arrive at a more accurate number. That work had been continued in the different countries of Europe, by Englishmen, by Frenchmen, and by Germans, and they had now numbers which agreed far better, so that they might assume that this number of 106·3 was right to about one in ten thousand. Therefore they were now able to give the statement of this value, which would, without doubt, be quite sufficient for all industrial purposes for a long time to come ; and it was a value which would be even sufficient for most scientific purposes. There therefore seemed no reason why the former definitions of the Paris Congress should remain. They had gone on in Germany, and it was considered that it was a task which ought to be performed by the Reichsanstalt, of which he (von Helmholtz) was President, and therefore the matter was brought before the Consulting Committee of the Reichsanstalt at the beginning of this year. They received information about that time of the English proposals, which were made rather earlier, and they found it quite reasonable on the whole to accept the numbers proposed by the Committee of the British Association

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and laid before the Board of Trade. There were only some special points in which they thought there should be any difference. They had found German silver, like many other alloys, particularly those which contained a little zinc, changed in resistance. If such a wire were wound round a coil it had a larger resistance than before; when it was manufactured its resistance altered within a period of some weeks, or even some months, so that they were never sure if two wires which originally had the same resistance had the same after some months. They found out other alloys, and principally those which had a small temperature coefficient. In using those alloys it was possible to get to a far higher degree of accuracy in comparing resistances than with others. Some of them were not very good for the constancy of their resistance; but after some time they found that an alloy, consisting principally of nickel and copper, had a very small temperature coefficient, and at the same time good mechanical qualities, so that if a new coil were wound, and it was heated several times in boiling water, a constant quality was obtained, and there was no change afterwards. These newer wire coils, made of such an alloy, when compared with mercury standards, were quite unalterable, as far as could be defined, during a period of one year. It was not sufficient that a good number of these resistances had been unaltered; if it happened that a wire coil which was to be used for centuries as a standard underwent changes—and they never could know what was taking place in its interior—many complications and difficulties would ensue. Therefore, they had come to the conclusion that it would be better to keep up the old definition of resistance given at first by Dr. Werner Siemens, the definition arrived at by means of a mercury column. They had many accurate experiments with regard to the definition of those mercury columns. One of his (the speaker's) assistants, Dr. Dorn, a very able worker, had found out some new errors which had not previously come under observation. He found that when such a mercury column in a narrow tube and surrounded by a thick tube of glass, even when surrounded by ice water, became heated; if only by $\frac{1}{2}$ of a degree it was sufficient, the resistance of such a mercury column was altered and the alteration could be measured. It was at the limits of observable alteration, but it could be measured and was quite regular. It was even possible to measure the degree of conductivity of the glass tube for heat by observing these little alterations of temperature. They must, therefore, suppose that all the observations of the resistance of mercury hitherto made had been a little too high, and that it was necessary to be careful in taking note of these alterations. Then there came out a very curious thing about the influence of the capillary force on the filling of the mercury tubes with mercury. It was demonstrated by these experiments of Dr. Dorn that the mercury did not quite completely touch the glass tube if it was not filled up in a vacuum, remaining under the influence of the vacuum for rather a long time. An easier way of filling was to bring a drop of petroleum between the mercury and the glass, when the mercury came immediately into contact with the glass, and they got less resistance in such a column of mercury than with any other methods of filling. That value of resistance which was the smallest was probably the right one; every other resistance which was a little greater showed that the filling was not complete. This was also a reason for determining that the mercury column should not be defined by the length and the diameter, for nobody could measure with absolute accuracy the internal diameter of a glass tube of a square millimetre section. This rendered it necessary to arrive at the determination by weight. It came out that, as far as it was possible to make the comparison, the English standards were in so good an agreement with the German independently-made standards, that there was no reason to go further for industrial purposes; for industrial purposes the accuracy was sufficient, he supposed he might say, for centuries. For scientific purposes there would, perhaps, be necessary some alterations in the determinations; but that was a question of time, and scientific people who had a good definition of standards could themselves make the little alterations that were necessary. He thought all the European nations, and North America as well, were very near to coming to an agreement, and if there was good will on all sides, the very unpleasant state of things which would result if they had different measures in different countries would be avoided. It was the object of the German scientists in coming there, being sent by their Government, to try to bring about an agreement with England at first, and they hoped that afterwards America and France would come into agreement also.

The PRESIDENT: This report may be taken as a proof that the work of the Association is not confined to one week in the year, but that it is going on all the year round, and that this week of meeting is really only the climax. We all greatly thank Dr. von Helmholtz for his statement, and also specially thank Mr. Glazebrook for the very great pains he has taken in this matter.

SECOND REPORT ON THE DEVELOPMENT OF GRAPHIC METHODS IN MECHANICAL SCIENCE.*

[ABSTRACT.]

BY PROF. H. S. HELE-SHAW, M.INST.C.E.

Three years ago a preliminary report was presented on the above subject by the Committee, consisting of Mr. W. H. Preece (Chairman), Mr. (now Sir) Benjamin Baker, Messrs. W. Anderson and G. Kapp, Profs. J. Perry and R. H. Smith, with the present writer as Secretary, who, at the meeting in the following year, was requested by the Sectional Committee to draw up and complete the report. Owing to causes which were explained in a letter to the Committee, last year, he was unable to do this in time for the following meeting, and now begs to present the result of his work up to the present time on the subject.

The preliminary report gave a list of a number of works which avowedly dealt with graphic methods; but, at the same time, it was stated that a large number of standard works, based to a great extent on such methods, or in which such methods were frequently applied, were excluded from the list. It does not require much acquaintance with the subject to realise that there is scarcely a treatise or publication dealing with mechanical science that does not employ some kind of graphical expression as a means of exposition or calculation. How great the range is may be gathered from a consideration that graphic methods really include every way of representing numerical quantities by means of drawing, except

1. The representation of actual bodies.
2. Purely geometrical construction.

Hence we have to go back very early in the history of mechanical science to find the first graphic treatment of the subject. A study of the list of references to graphic applications in scientific literature of this country appended to this report will show that gradually, but with an ever-increasing rate, it has become the custom to employ representations of numerical results graphically, and to suggest and use the solutions of various problems by graphic methods.

These two purposes, viz.:—

1. Representation of results by means of plotted curves and autographic diagrams,
2. Solution of problems by graphical methods,

seem to suggest a satisfactory way of dealing with the subject.

At the same time no hard and fast distinction must be insisted on, because a curve, although chiefly useful for the purposes of representing the general results of an experiment or calculation, may be employed by means of interpolation or otherwise to effect a calculation.

Now it would be quite legitimate in this report to trace the development of the manner of representing results, and also of the building up of geometrical theories which are employed for purposes of graphical calculation. For the former, however, the best method of procedure is to state the results which have been achieved, as this aspect is the practical and useful one.

Inasmuch as every possible kind of numerical quantity can be plotted, it would not be possible, even if it were desirable, to give anything like a complete list of the subjects which have been or may be plotted. Further, in dealing with the instruments used as self-recording or otherwise, there must be omissions, because descriptions of many such instruments are not to be found anywhere; hence the object in dealing with this part of the report has been to give a clear statement which will convey an idea of the progress and present state of the subject. Moreover, the appended list of references obviates to a great extent detailed references to authorities and journals when dealing with the descriptive portion.

The fact is, the difficulty of ascertaining what subjects in mechanical engineering have been treated graphically in current literature, is very great. Nothing less than an examination of every page of engineering journals and scientific papers suffices for this purpose, since no intimation is usually given in the index, hence the list of references which has been added is arranged under suitable headings of the more important applications of mechanical science, wherever such applications have been treated graphically. In one column the names of the subjects are given under which the article is found in the journal—in another, the description of the graphic diagram—in another, the author's name. The arrangement of matter under each heading is in the order of the year of publication, so that anyone searching for graphical records on a certain subject will see at once what is old and what is new.

Very different, however, is the case of the graphical treatment of problems. This is a subject of very divided opinion, whereas the mere representation of results has settled down into recognised lines and methods of operation. Great as the progress has been in this direction, it will be seen that there is a wide field for discussion in the present state of the question, hence in this portion of the report an attempt has been made to present the views of different schools of thought, and to state the results achieved up to the present. At the same time the question is far too wide to be treated in the present report in a way at all justified by its importance, and it is a question for the Section to decide whether a further report dealing more fully with foreign literature and practice in graphic methods in relation to mechanical science is not desirable.

To the treatment of the two subjects thus divided there is prefixed a statement of the geometrical principles involved in the methods of graphical representation. This preliminary statement is necessary to show both the possibilities and methods of graphical

* British Association, Section G, Edinburgh, August, 1892.

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records, as well as to premise the considerations in the second portion dealing with calculation.

The foregoing remarks will explain the following scheme of the report.

SCHEME OF REPORT.

I.—*Geometrical Considerations involved in (1) the Representation of Results Graphically, and in (2) Graphical Calculations.*

1. Use of one dimension of space corresponding to measurement from one fixed point in a plane, enabling one variable to be dealt with. The use of two dimensions of space corresponding to the measurement from two fixed points in a plane, enabling the position of a point to represent two variable quantities. The use of three dimensions, or of representation of three variables by the positions of a point involving the use of models or stereotomy, is excluded from consideration in treating of graphical methods.

2. Practical distinction between analytical treatment and geometry of position. The graphical calculus.

II.—*The Representation of Results.*

1. The plotting of diagrams; the use of squared paper. Growth of the method. Plotted tables. Contributions on Naval Architecture by Mr. H. H. West; and on Electrical Work, by Mr. F. G. Baily. Applications in civil and mechanical engineering.

2. Instruments for drawing known curves used with graphical methods Improvements in simple drawing instruments. Elliptographs, drawing the parabola. Harmonic curves; the involute; cycloid; spirals, &c. The gabarit. The integraph.

3. Self-recording instruments. Marking arrangements. Modes of actuating surface for receiving the record. The movement of the recording arrangement. Instruments for recording (*a*) levels, (*b*) pressure, (*c*) magnetic attraction, (*d*) velocity, (*e*) temperature, (*f*) vibrations and shocks, (*g*) results and mathematical operations, (*h*) chronographic results.

III.—*Graphical Solution of Problems.*

1. Consideration of modern methods of graphical calculation, chiefly in view of continental use and opinions concerning the application of projective geometry in graphic statics.

2. Addition of parallel segments. Sliding calculation and slide rules. Shearing force and load diagrams.

3. Addition of non-parallel segments. Summary of the applications of the principle of reciprocal figures.

4. Graphical multiplication. Culmann's method. The rectification and calculation of areas. Planimeters and integrators. Summary of the problems in engineering to which methods of graphical multiplication are applied.

IV.—*Classified List of Reference to Graphical Methods.*

List of transactions, proceedings, and periodicals from which references are taken.

Alphabetical list of subjects, under which the references are classified in order of the year of publication.

(*Here follows list of References.*)

EARTH CURRENTS.

In connection with the recent earth-current disturbances and Mr. Preece's Paper thereon at the British Association, the following new Post Office form of report will be of interest:—

Date.	Name of circuit affected (codes not to be used).	Relative geographical position of terminal offices with respect to each other.	Greenwich time (state a.m. or p.m.).		Current.		Deflection shown on instrument galvanometer when switch turned to simplex.	Circuits not affected by earth currents at the same time as the others.		Remarks.
			Commenced.	Ceased or changed direction.	Direction.	Strength in milliamperes.		Name of circuit.	Relative geograph cal position of terminal offices with respect to each other.	
			H. M.	H. M.						
Aug. 4	Portrush ...	N.W.	7.30 p.m.	7.45 p m.	neg.	5·1	.....	Londonderry 1 & 2	S.W.	
								Ballymena.....	S.E.	
„	Sligo	S.W.	„ „	„ „	„	4·6	.. ...	Enniskillen	N.W.	
„	Coleraine ...	N.W.	7.45 p.m.	7.50 p.m.	pos.	1 to 7	.....	Londonderry 1 & 2	N.E.	
								Ballymena.....	S.E.	
„	Omagh	W.	„ „	7.55 p.m.	„	1·2	.....	Londonderry 3.....	S.	
„	Portrush ...	N.W.	7.50 p.m.	8.5 p.m.	„	8 to 21·2	.....	Londonderry 1 & 2	S.W.	
								Ballymena . ..	S.E.	
„	Coleraine ...	N.W.	„ „	8 p.m.	„	2·4	.....	Londonderry 1 & 2	S.W.	
								Ballymena	S.E.	

* The direction of the received current is positive or negative when it flows into the station, either as a copper or as a zinc current respectively from the terminal point

THE LONDON OVERHEAD WIRES ACT, 1891—COUNTY COUNCIL BYE-LAWS.

In our issue of December 11, 1891, we published a set of by-laws relating to overhead wires, which had been approved by the London County Council, but not by the Board of Trade. We print below the by-laws as finally amended and approved by the Board of Trade on July 29th.

In these by-laws—

The expression "the Act" means the London Overhead Wires Act, 1891.

The expression "wire" has the same meaning as in the Act, except that it does not include any support or attachment.

The expression "cable" means any covered or insulated wire, of which the diameter to the outside of the covering exceeds twice the diameter of the bare wire, and where more wires than one are enclosed in the same covering or insulation, includes all such wires and covering, without reference to diameter.

General.

1. The Company shall deliver to the Council and the Local Authority full particulars of the material and gauge of the wires of the Company, and the nature and position of the several supports, and the length of span between the several supports. The Company shall also deliver to the Council a plan, on a scale of not less than 25in. to the mile, showing the routes of such wires, and the position of the supports or at their option shall cause the routes of such wires and the position of the supports to be marked upon a map to be supplied for the purpose at the office of the Council.

Existing Wires.

2. In the case of wires or supports existing at the date of the approval of these by-laws the Company shall comply with the requirements of by-law 1 within six months after that date.

New Wires.

3. In the case of new wires or supports placed after the date of the approval of these by-laws, the Company shall comply with the requirements of by-law 1 within one month after the placing thereof.

4. A wire shall not be placed so as at any point to be at a less height above the ground than 20ft., or, where it crosses a street, 35ft., or at a less height above the roof of any building than 6ft., except where it is brought into any building for use in that building, or is attached to a chimney or other part of a building in accordance with these by-laws.

5. Every wire shall be supported at intervals not exceeding 115 yards, unless permission in writing be obtained from the Council and the Local Authority for a longer span.

6. Every support for a wire shall be of durable material, and properly stayed against forces due to wind pressure, change of direction of the wires, and unequal length of span; and all independent conductors and suspending wires shall be securely attached to the supports.

7. The factor of safety for all stresses arising from the weight of conductors and suspending wires shall be at least four at a temperature of 22° F. The factor of safety for all other parts of the structures shall be at least ten, taking the maximum possible wind pressure against a support acting in a horizontal direction at 30lb. per square foot. No addition need be made for a possible accumulation of snow.

8. Every support for a wire shall be marked in such manner to be approved in the case of each company by the Council as to identify the company to whom it belongs.

9. Where a support is used for the wires of more than one company, the company owning the support shall be responsible for the support and the attachment of the wires thereto.

10. No cable shall exceed one pound per lineal foot in weight; and every cable shall be carried by independent suspending wires and attached to the same by efficient slings.

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11. Every iron or steel wire, and every iron or steel support or attachment, shall be efficiently protected from oxydation.

12. All poles erected on buildings as supports for wires, unless fixed through the roof, shall be carried on shoes or saddles properly protected from oxydation, and shall be efficiently stayed, so that in the event of a pole breaking it shall be impossible for it to fall into any street.

13. Every wire attached to a chimney, wall, or other part of a building, shall be efficiently supported by angle plates of iron or bronze or other device approved by the Local Authority.

14. Every wire support and attachment shall be duly and efficiently supervised and maintained by the company.

15. No wire support or attachment shall be in such a condition that danger to the public using the streets may be apprehended therefrom; and the Company to whom any wire support or attachment being in such condition belongs, shall be guilty of an offence against these by-laws.

16. No wire support or attachment shall remain erected after it has ceased to be in use, unless the Company intend within a reasonable time to take it again into use, and give notice of such intention to the Council and the Local Authority.

17. On reasonable notice being given by the Council or the Local Authority to the Company, access at all reasonable times for the purpose of inspection of the Company's wires, supports, and attachments shall be given or secured by the Company to the inspectors of the Council and the Local Authority.

Penalties.

18. Any company or person failing to comply with any of these by-laws, or of the provisions of the London Overhead Wires Act, 1891, or delivering any particulars which to their or his knowledge are incorrect, shall be guilty of an offence against these by-laws, and shall be liable to a penalty not exceeding £5, and to a further penalty not exceeding 40s. for each day during which such offence is continued after conviction thereof.

[N.B.—The Act (see section 18) does not extend to any wire placed by any person for his private use over land belonging to him or in his occupation, which does not extend over any street thereof or attachment, and is so constructed and placed that neither the wire nor any support, thereto would be liable to fall into any public street.]

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 12, 1892.

The Toronto Meeting of the Association of Edison Illuminating Companies.—The eighth annual meeting of the Association of Edison Illuminating Companies met in Toronto on Tuesday of this week. About 50 members were present to discuss questions which are considered of the greatest importance to those who are operating Edison central stations. Since the consolidation of the Edison and Thomson-Houston Companies was accomplished it has been thought by some that the Edison Association would of necessity take steps to consolidate with the National Electric Light Association. Such, however, does not seem to be the intention of the Association, and, considering the action taken at the recent meeting, it is more likely that the membership will be extended so as to include those who are operating other than Edison stations. This has always been the tendency of the managers of the electric light companies in this country; that is to say, to meet together and consider subjects which are of the greatest importance from an economical and financial point of view, the proceedings of the convention, however, being always withheld from publication. The convention held this week is no exception to the rule, only those who were members being given an opportunity of listening to the discussions. Mr. C. A. Coffin was present at one of the sessions, and took part in the discussion of certain questions regarding the business policy of operating companies. The most important Paper presented was that of Mr. J. H. Vail on "The Application of New Apparatus and High Economy Engines in Central Stations to Secure Greater Commercial Efficiency and Economy of Coal." Mr. Vail took up the discussion of the introduction of triple expansion engines into central stations, to be operated by direct connection to the armatures of multipolar generators, as well as the question of using improved methods for obtaining a high economy in the consumption of coal. One of the interesting features of the convention was the presentation by Mr. William Lloyd Garrison, of Boston, of his pioneer experience in incandescent electric lighting at Brockton, Mass., in one of the earliest Edison Central stations, and the one in which the first underground three-wire system was operated on a commercial scale.

CORRESPONDENCE.

THE DIMENSIONS OF PHYSICAL QUANTITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I expected, "W. M. M." has again failed to answer the simple question I put to him.

In transforming the equation $t\,[T] = l\,[L]$ into another form I was careful to give the meaning of every one of the new symbols. It is therefore remarkable that "W. M. M." should put forward an argument which is entirely invalidated by the fact that a and b are variables. It is evidently necessary "to define my position" in the very simplest terms. I therefore submit that $[L] = 2$ is an equation, that it is perfectly valid if $[L]$ is abstract, but is false by Fourier's rule and by the definition of the symbol $[L]$. Hence $[L]$ is not abstract.

I am at present travelling, and am not seeing *The Electrician* regularly. This accounts for the fact that this letter is tardy; and as similar difficulties will beset my correspondence for some weeks to come I must ask you to allow what follows to close this series of letters as far as I am concerned.

The difficulties of "W. M. M." are due to the fact that he fails to see that the dimensional notation is expressly intended to meet them. Maxwell explains this as clearly as possible in the passage I quoted, but "W. M. M.," with strange perversity, twists his words into a sense diametrically opposed to what he himself admits is their more obvious—and, as I have no hesitation in saying, is their true—meaning.

By separating the symbols which represent the abstract multipliers and the concrete units respectively we are free to perform arithmetical operations with the former and to attach any meaning we please to symbols which are written as algebraical products or divisors of the latter. We are not bound to regard $\left[\frac{L}{T}\right]$ as a length divided by a time.

It is a symbol for a concrete velocity which conveniently expresses the relations of the unit velocity to the concrete units of length and time. The view of "W. M. M." is like that of a student who might insist that $\frac{du}{dt}$ is always $= \frac{u}{t}$ because (as he would say) the d's cancel in the numerator and denominator. I am quite aware that my view is not free from difficulties, but they are fast disappearing by investigations such as that of Mr. Williams. They certainly are not such as to drive me to the absurd conclusion that such an equation as $[L] = 2$ is valid.—Yours, &c., ARTHUR W. RÜCKER.

ELECTRICAL UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May we who actually handle electrical units every day of our lives contribute a word to this discussion? We have for so many years treated the total induction as the important quantity in magnetics, and altogether ignored the illusory formula $\mathsf{B} = \mathsf{H} + 4\pi\mathsf{I}$, that we cannot help rejoicing to see how one by one the shining lights of the professorial world are quietly omitting all reference to $4\pi\mathsf{I}$, and speaking of ampere-turns and total induction as cause and effect.

Those whose business it was to measure these things every day very soon felt the need of a name less cumbrous and dogmatic than "one line of force," and following the precedent set by those who coined the word *farad* we proposed to call the unit of total induction a *thom*. And why not? The sole reason against this convenient name has disappeared with the translation of Sir William Thomson to another sphere, and some of us who remember him with affection would like to be reminded of him every time we measure an induction.

But now Dr. Lodge proposes to solidify 100,000,000 thoms into one magnificent unit, and call it a weber; for much the same reason as led the B. A. to define the farad. No doubt the fact that *if* you thread one weber into a circuit in one second you can get an E.M.F. of one volt has an attractive simplicity about it; so has that other fact, that if you charge a farad up to one volt it holds a coulomb. Only nobody really does either of these things—partly because they do not want to, but chiefly because they cannot. We generally have

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to do the best we can with a great deal less than a weber, and if the induction cannot be put into the circuit in the twinkling of an eye it is not worth using.

Consider a few examples, taken at random, of such inductions as are continually dealt with in a works test-room :—

	Thoms.	Webers.
Total induction threading coil of our standard of induction	1273	·00001273
Coil of a gravity ammeter	900	·000009
A ship's telegraph needle	9000	·00009
A generator magnet	8000	·00008
A generator armature	25000	·00025
A 12-kilowatt armature	$3·7 \times 10^6$	·037
A 120-kilowatt „	26×10^6	·26

Is it not obvious that a weber is absurdly large? Do not compel us to use negative powers of 10, we would far rather muddle along with the old 10^8. It is true that the thom is a very small unit—so is the second ; but *million thoms* is quite as easily written as *microwebers*, and more easily understood.

The desire to name units after Gauss and Weber is very natural as a compliment to the German nation ; but the use of those names cannot add a jot or tittle to the honour in which they are held by the whole scientific world. The name gauss should however be allowed to drop, solely for euphonious reasons—gausses is unbearable ; but the unit magnetic force might be christened a *weber* if our suggested *thom* is adopted.

We have another reason for desiring to name the induction unit ourselves ; in adopting the *thom* the B. A. and the Professors would be paying a delicate compliment to him for whose convenience all units are devised—the despised "practician."—Yours, &c.,

SYDNEY EVERSHED.
ERNEST B. VIGNOLES.

Woodfield Works, W., Aug. 23, 1892.

THE COST OF THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : Could some of your readers give from actual experience, under different circumstances and in different districts, particulars of what electric light supplied from central stations has cost them, mentioning cost of installation, rent of meter, supply bill, and any other expenses, and the size of the house. I, for one, should be grateful for this information, and I think it would be generally useful.—Yours faithfully,

August 18, 1892. ROBT. LEHFELDT.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Administration of the Belgian State Railways in Brussels invites tenders (to be opened at 11:45 a.m. on the 31st inst.) for the installation of the necessary machinery and apparatus for the electric lighting of the station at Ath.

——— The Direction Général des Postes et des Télégraphes invite tenders for the supply of 100,000 kilogrammes of high conductivity copper wire and 6,000 couplings for this wire. Forms of tender must be obtained from 103, Rue de Grenelles, Paris, before Monday next, and the tenders will be opened at 11 a.m. on the 8th prox.

——— Tenders for lighting the city of Belem do Gram-Parà, United States of Brazil, by gas or electricity, will be received up to November 30th next at the office of the Secretary to the Municipal Council. Particulars can be had on application to the Brazilian Legation, 55, Curzon-street, Mayfair, W. (where a plan of the said city may be seen), or to the Brazilian Consul-General, 6, Great Winchester-street, London, E.C.

POOLE AND WHITE (LIMITED).—A petition for the winding up of this Company was down for hearing before the Vacation Judge on Wednesday, but we have authority for announcing that the case was withdrawn before being reached.

THOMAS BARRACLOUGH AND CO. (LIMITED).—Claims against this Company (in voluntary liquidation) must reach the liquidator, Mr. Alfred Tongue, 44, Brown-street, Manchester, by September 24th.

BANKRUPTCY PROCEEDINGS.—Mr. Rankin Kennedy, electrical engineer, Carntyne Electrical Works, Glasgow, was examined in bankruptcy on Monday in the County Buildings, Glasgow, before Sheriff Birnie. The state of affairs showed the net assets to amount to £2,055. 2s. 5d., and the liabilities to £714. 14s. 9d. The bankrupt considered that his assets should realise sufficient to pay 20s. in the £1 to his creditors and leave a surplus. The cause of his difficulties was insufficiency of capital to carry on his contracts, and certain creditors having lodged arrestments and otherwise taken proceedings. The examination was closed.

ATELIERS HOSTER DE ST. NICHOLAS (LIMITED). — The first meetings of creditors and of contributories of this Company (in liquidation) will be held at 33, Carey-street, W.C., on Wednesday next, the 31st inst., at 11 and 11.30 respectively.

PARTNERSHIP DISSOLVED.—The partnership between Messrs Grist and Turner, carrying on business at 33, Gracechurch-street, E.C., as electrical engineers and contractors, has been dissolved. Debts will be paid by Mr. C. J. Grist.

MESSRS. G. E. BELLIS AND CO.—Mr. Willoughby Warden, 60, Robertson-street, Glasgow, has been appointed representative of the above firm for Scotland and Belfast.

THE CRYSTAL PALACE EXHIBITION.—We have received from the Harburg India Rubber Company a souvenir of the recent Exhibition at the Crystal Palace. This souvenir takes the form of a medal worked in vulcanite, set in a neat case, and accompanied by some friendly remarks from Mr. F. Winter, who represents the Harburg Company in this country. It appears that the Company have been sending out samples of their specialities to electrical firms who have obtained prizes at the Exhibition ; in each case the samples have taken the form of the medal referred to, the execution of which reflects much credit upon the Company. About 800 persons are engaged in the manufacture of vulcanite articles for electrical engineers, &c.; and the firm claim that they have amongst their customers the leading electrical houses, in addition to the chief European Governments. The medal certainly forms an admirable advertisement for Mr. Winter's firm.

MR. LEOLINE A. EDWARDS.—This gentleman has been appointed sole London representative of Messrs. T. L. Hemming and Co. (Limited).

MESSRS. ANDERSON AND MUNRO.—This firm have several electric light installations on hand, amongst them being one for Sir Archibald Edmonstoun, Bart., at Duntreath Castle, and one for Mr. George Neilson at Cressbasket. The former is for 200 8 c.p. and 100 16 c.p. lamps, the current being supplied by a Goolden dynamo, and the latter for 175 16 c.p. lamps, fed by a Siemens dynamo. Turbines are the prime movers in each instance.

MESSRS. ERNEST SCOTT AND MOUNTAIN (LIMITED).—This firm have secured the contract for lighting the Co-operative Wholesale Society's premises at Newcastle-on-Tyne ; the installation consisting of three 25 H.P. gas engines and three Tyne compound-wound dynamos. Other contracts recently secured by the firm are lighting the Ashington Colliery and Messrs. Chadwick Brothers' mill in Russia, in addition to an electric pumping plant for the Newton Colliery Company.

TELEGRAPH MESSENGERS.—The late Postmaster-General during his term of office gave particular attention to the appearance and bearing of the telegraph messengers. Arrangements have been made that the lads attached to the principal offices shall be drilled ; and the late Postmaster-General acknowledges the assistance he has received from the commanding officers of several Volunteer regiments in allowing the use of their drill halls, and to the Master of the Charterhouse for the use of the picturesque grounds of that Institution, where, on the 18th instant, some 300 of these messenger boys, under the command of Major J. P. Macgregor of the Post Office Volunteers, were inspected by Sir A. Blackwood, Secretary to the Post Office. Sir Arthur congratulated the lads upon their appearance, and indicated that since the commencement of the drilling, greater attention and care had been paid to their uniforms and to their general appearance.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

August 4, 1892.

14,064. W. ALDRED. Sheffield. A continuous direct electric current machine and motor.

14,089. C. C. LESENBERG and J. VON DER POPPENBURG. London. Improvements in dry batteries.

14,096. G. H. CHURCH. London. Improvements in automatic electric arc lamps.

August 5, 1892.

14,160. G. S. GRIMSTON. London. Electric apparatus for working the elevating and training gear of guns and the lifts for their ammunition.

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14,180. J. L. DOBELL. London. Improvements in or connected with electric batteries.

14,181. C. P. SHREWSBURY and J. L. DOBELL. London. Improvements in or connected with electric batteries.

14,189, H. H. LAKE. London. An improved method of and apparatus for distributing alternating electric currents. (W. Stanley, jun., and J. F. Kelly, United States.)

14,193. A. FRANKE. London. Improvements in or relating to electrically-controlled valves.

August 6, 1892.

14,199. A. A. DAY. London. A new and improved form of electric testing instrument.

14,206. J. L. DOBELL. London. Improvements in or connected with electric batteries.

14,229 H. SKONE. Manchester. Improvements in incandescent electric lamp holders.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

12,602. ARON. Measuring electric currents.

12,831. RUSSELL. Curative electric belts, &c.

13,961. BENNETT. Electrical parcel exchange system.

14,217. SACCO AND GIACOMINI. Telegraphic apparatus.

14,817. HEYS (Brown). Electric tram-cars.

15,768. HALL. Distributing electricity.

16,090. PITT. Telegraph posts.

16,091. MASSEY. Electric circuits for lighting.

17,160. LAKE. (Soc. dite Electriciteits Maatschappij Système de Khotinsky.) Electric accumulators.

17,231. SIEMENS BROS. AND CO. AND OTHERS. Winding for drum armatures of dynamos, &c.

1892.

1,497. SHIELS. Couplings for electric wires.

11,403. GOOLDEN AND ATKINSON. Electric generators and motors.

11,424. DYMOND (Strowger.) Telephone, &c., exchanges.

11,692. PURDON AND OTHERS. Electric locomotives.

11,698. MEYER. Insulators for electric wires.

COMPANIES' MEETINGS & REPORTS.

Telephone Company of Ireland (Limited).

The half-yearly general meeting of the shareholders of the Telephone Company of Ireland was held on Thursday at the Commercial Buildings, Dublin. The Chairman of the Company, Alderman V. B. Dillon, presided.

The CHAIRMAN moved the adoption of the report (which appeared in *The Electrician* of the 5th inst.) and accounts. He said they had on their books between 400 and 500 shareholders, and it was gratifying to find that the report was so satisfactory that practically the attendance of shareholders was nil. It was satisfactory, although the Company had been obliged, owing to the large expenditure upon the capital account, to postpone payment, for the present, of any dividend. The Company had constructed out of their revenue account a trunk line connecting Dublin and Belfast. They had absorbed a considerable revenue which they had made during the year, and while the Company had in cash sufficient funds to pay the dividend, they had thought it more for the advantage of the shareholders to postpone paying it for the present. He was bound to congratulate the shareholders upon the progress which the Company had made since they last met. The number of wires on December 31, 1890, was 1,473, and at the present moment it was nearly 1,600, being an increase of over 100 wires, while they had now 27 orders in hand for wires in course of construction. The Company had now exchanges in Dublin, Cork and Limerick, and they were opening exchanges in Dundalk, Drogheda and Balbriggan, towns in the district which had been connected with the Company by trunk wire; and so soon as the Government carried out their proposals of connecting other cities such as Waterford, Kilkenny, Galway and other large towns in the West and South of Ireland, the Company trusted to open exchanges in these places, and to give them the facilities of inter-communication, not only with towns in Ireland, but, so soon as the development of the system foreshadowed by the Post Office takes place, with towns in England and Scotland; and ultimately telephonic communication with France and the Continent. The shareholders would, he thought, be interested to know what the Government had proposed to do in connection with telephones. They propose to connect every important town in Great Britain and Ireland with every other town by means of trunk lines. They propose to connect England and Ireland with the cable for telephonic purposes as the cable between London and Paris. They propose to allow call houses, and he hoped to see exchanges established in all sub-post offices. So that after a short time they looked forward to having a telephone wherever a telegraph office exists. They would now allow telegrams to be sent by telephone. Hitherto everybody using the telephone had to go to the Post Office to deliver a telegram, but now, after a few weeks, he trusted that users of telephones would be able to telephone their messages to the Post Office, and to have them written down without any charge being made by the Post Office authorities and transmitted. Although these changes were very important they were only some of those which were to be proposed in that way; and if the Government would endeavour to work that telephonic system with the same enterprise that they had worked the telegraph system since the introduction of cheap telegrams, after a short time it would revolutionise completely the mode of communication in these countries, and they would find that people, instead of sending telegrams, would adopt the telephone almost universally. He trusted that when the Government carried out their proposals they would make the charges so reasonable, particularly in this country, where the volume of business was not large, that the system would be adopted at once. With these observations, which he hoped might be interesting to the shareholders, he begged to move the adoption of the report and statement of accounts.

Mr. G. COCKBURN seconded the motion, which was adopted.

The CHAIRMAN moved, and Mr. COCKBURN seconded, that Mr. Arthur Dudgeon be elected a Director of the Company, which was carried.

Mr. John M. Keane having been re-elected auditor to the Company, the meeting concluded.

Birmingham Central Tramways Company (Limited).

The eleventh ordinary general meeting of shareholders was held on Wednesday at the Queen's Hotel, Birmingham, under the presidency of Mr. Joseph Ebbsmith.

The report and statement of accounts having been taken as read,

The CHAIRMAN then said that from a public point of view the working of the Company during the past year had been eminently satisfactory. They had carried a million and a-half more passengers—namely, 25,718,000, against 24,381,000 last year. When, however, they took the report from the point of view which more immediately concerned them as shareholders, that of the net profit which had been made, the results were found to be that, although their traffic receipts had risen from £143,000 to £152,000, their working profits had sunk from £43,000 to £37,000. It had been his custom somewhat minutely, year by year, to criticise the various items of receipt and expenditure, and for that purpose he had been supplied with an analytical statement from the Managing Director, a copy of which had been supplied to each shareholder as he entered the room. Mr. Wain had been continually pressing the Directors to purchase thirty heavier steam engines than those now in use; but the Directors shrank from the expenditure of such a large sum until they had a better understanding with the local authority with respect to the repair of the roads, and they thought it would be better to overwork their engines for a time rather than spend a sum of money which might possibly be found to be sunk altogether. It would not be fitting that they should pass lightly over what was in his opinion the most serious factor in the report—namely, the results of the working of the electric department. They would recollect that in this matter they were on the horns of a dilemma. They were committed to the completion of the Bristol-road route under certain contracts by cable; and they were aware that exactly as the cable was a gold mine on suitable lines, so it was a sink for money where the traffic was not sufficient, and where the lines were not suitable. At the same time they had heard of the wonders that were to be accomplished by electricity, and the most sanguine results were foreshadowed. The policy which the Board adopted was laid before the shareholders and approved by them; and now, looking at the accounts of the electric department, he was glad to say that the matter stood far more hopefully than it impressed him at the first blush. It was necessary for them to consider what were the leakages before they could say what would be the permanent loss. There were two causes of leakage which ought to be, and he trusted would be, stopped. After alluding to the charges made by the Corporation for repairs of roads, the Chairman said that there was another matter which came more immediately within their own ken, and that was the cost of maintenance of batteries upon the Bristol Road route, and which had been simply monstrous. It had amounted, roughly speaking, to 3d. per mile run in the sense of what he might term engine-power. This, too, was a matter which was pressed upon them by their Managing Director, the necessity of providing additional batteries to maintain the traffic upon that route. But this was too startling a matter to be dealt with hastily. They recollected their experience with the cable. When the cable route was opened one of the most able manufacturers supplied them with ropes, and the first lasted them six weeks, with the result that instead of the profit they expected they saw nothing but disastrous loss before them. What they did was this—they went to the various rope-makers and said to them, "We do not care of what or how you make the rope, but we want a rope that will last, and on what terms will you make a contract to supply us for three years with ropes?" This proved satisfactory, and they had now adopted the same principle with regard to the batteries under terms which meant a penny per mile instead of threepence. The Chairman went on to explain the course of business which he proposed to adopt, stating that he should submit a series of resolutions dealing with the separate recommendations of the report, and proposed first of all the payment of a dividend of 5 per cent. on the preference shares.

Mr. M. J. SMITH seconded the motion, and it was carried.

The CHAIRMAN then moved that the balance of £13,921 should be carried forward pending the decision of the Public Works Committee, and the decision of a subsequent meeting as to the reduction of capital, but afterwards withdrew the resolution, and moved that a committee of shareholders be appointed to assist the Directors on the question of dealing with the Corporation, and to confer with them on the question of reduction of capital.

Mr. NEALE having seconded this latter resolution,

Mr. LIVESEY proposed, as an amendment, to omit the words relating to the reduction of capital, as they would never get a better meeting than that to discuss the subject.

The amendment was seconded, and after some discussion it was carried, and the committee were then appointed.

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A letter from the Chairman to the solicitors was then read, in which he expressed a desire to resign his position as Chairman.

A motion for the re election of the retiring Directors was defeated on a vote; but the Chairman demanded a poll, which resulted in the motion being carried.

The retiring auditors were re-elected; and the meeting, which had at times been rather stormy, terminated.

That portion of the Managing Director's report relating to the electric department was as follows:—"I regret that my own idea as to the traffic upon this line has not been justified by the result. You will remember that my estimate of the traffic was an average taking the year through of £250 per week; but the failure to reach this figure arises from causes with which you are well acquainted. There is no doubt that if we had had the means at our disposal to have conveyed the traffic my estimate would have been fully justified. One set of the new batteries has been delivered. Had we been able to maintain the service originally contemplated, the difference in traffic would have been £2,700, which would have converted the deficit into a profit of £1,000. The undue strain put upon the rolling stock, owing to the lines having been so constructed by the Corporation that they were too wide for the cars—*i.e.*, that they were out of gauge to the extent of as much as 1⅛in., resulting in the constant breakage of axles and wheels, and the consequent effect upon the working parts, and the enormous consequent strain upon the batteries, which were practically trying to grind a new groove in the metals, has naturally increased the maintenance charges to a very high figure. Again, the charge for permanent way is monstrous. It is absolutely impossible that ordinary repairs to a line which has only been constructed two years could have in the past twelve months cost the sum of £1,352. That this is so is shown by the fact that on the small portion of line belonging to us beyond the city boundary on this route we have spent practically nothing during that time. The electric expenses in fuel will show a reduction this year. The new boiler will be able to do the bulk of the work, and, owing to the price of fuel generally being reduced, we have been able to make a contract more advantageous to the Company. After making many inquiries we have negotiated an arrangement with a company under which they guarantee, after the first cost of batteries is paid, to keep them in repair and renew them when required for one penny per car mile run. The recent reduction in the electric service (which has, as the daily returns show, worked for the past few months with scarcely a hitch) has been due to the diminution of the number of batteries available for working, owing to others being worn out; and during that time the desire of the Board not to incur indefinite expenses in batteries, pending the investigation then in progress. A suggestion has been made that the electric and cable cars should be canopied. The Company would have no objection if the Board of Trade and local authorities would agree to it, although it would add considerably to the weight, and, therefore, to the cost of haulage; but the local authorities have hitherto declined to allow canopies to be placed upon the cable cars."

Hong Kong Electric Company (Limited).

The third annual ordinary meeting of this Company was held on June 11 at Hong Kong; Mr. H. L. Dalrymple presiding.

The CHAIRMAN said he did not know that he could usefully supplement the information conveyed by the manager's report attached to the accounts, which gave a concise statement of the progress made in the Company's business during the past twelve months. He regretted that the branch of incandescent lighting had not been more extended, but he thought the cause was not far to seek, and they must continue to hope that when the Colony returned to its normal state of prosperity, the hopes entertained when this Company was formed would be realised and enable the Directors to make some tangible return to the shareholders. The working of the Company for the twelve months showed an advance in the right direction, and in another year's time they would see themselves in a still better position. He must, however, point out to, and urge on, their numerous friends that on their increased support and appreciation of the manifest advantages of the electric light the success of the Company largely depended. Their plant was capable of supplying a very large addition to the amount of incandescent light at present in operation, so that the increased consumption would materially augment the revenue at a minimum extra outlay. He moved the adoption of the report and accounts.

The motion having been seconded and carried,

Messrs. J. J. Bell-Irving and J. Kramer were elected Directors in the place of Messrs. Keswick and Poesneckern (resigned), and the Hon. C. P. Chater and Mr. T. E. Davies were re-elected Directors.

City of London Electric Lighting Company (Limited).

The following report, for the period ended June 30th, to be presented to the shareholders at the second annual general meeting of the Company, to be held at Winchester House, E.C., on Thursday, September 1st, at 2:30 p.m., has been issued:—

The Directors state that they have constantly pressed forward the necessary work, and the progress made is satisfactory. All the Provisional Orders and contracts are now in the possession of the Company, and the former have received the Royal assent. The Directors have secured on favourable terms the freehold of the Bankside Central Station, and have entered into an "agreement for a lease" of 90 years for the other central station at Wool Quay. Suitable buildings have been erected for all plant now running. Additional buildings for the machinery on order are in progress, the work for which is being carried on by night and day. Sites for several transformer stations have also been acquired, and the necessary work of construction and equipment is far advanced.

Contracts for the full equipment of plant for the generating stations have been entered into under such conditions and specifications as will ensure all material and work being of the highest class and efficiency. There is already installed machinery of a capacity of 700 public arc lamps, and 23,000 8-c.p. glow lamps, including reserve. Additional machinery of a capacity of 56,000 8 c.p. glow lamps is being constructed; part of this is expected to be running by the end of October, and the remainder in the early part of 1893.

The arrangements for duly executing street work within the limited time allowed by the contracts formed the subject of serious consideration by the Board. With the object of avoiding the inconvenience to the public inseparable from frequent opening of the same streets, it was decided to lay, at one operation, "ways" sufficient for immediate requirements, together with a number of spare tubes to meet all probable developments of the Company's business. By recent legislation, electrical supply companies are authorised, subject to certain consents, to lease for telephonic purposes any spare tubes they may have.

In reference to public lighting, the report states that 184 arc street lamps were in use on June 30th, and that the greater number of lamps contracted for will be in operation by about the middle of September. The final date for completion specified in the contracts is the 5th November next.

The demand for private lighting continues to be exceedingly good. On June 30th, signed applications had been received for 32,028 lamps, chiefly from the limited area in which the current was then available. Of this number 11,860 were connected up.

The Directors have endeavoured to make their capital outlay earn revenue at the earliest possible moment, having regard to the proper execution of the work and the provision of adequate reserve power. The result is that a considerable income is already accruing. Public and private lamps installed at June 30th were estimated to be earning at the rate of £14,600 per annum, a figure which is daily increasing. From calculations based on the lamps already connected to the Company's mains, it appears that the consumption of current per lamp installed in City offices, shops, &c., will be much greater than was anticipated. There is every indication that the position of the Company is exceptionally favourable.

Messrs. W. H. Pannell and Co. retire, and, being eligible, offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

COMPOUND MOTOR COMPANY (LIMITED).—This Company was registered on August 18th, with a capital of £200, in 1s. shares, to carry on the business of engineers, merchants, railway and tramway contractors, locomotive engine builders, &c.

JOHN H. WILSON AND CO. (LIMITED).—This Company was registered on August 19th, with a capital of £20,000, divided into 1,500 £6 per Cent. Preference and 500 ordinary shares of £10 each. The objects are to acquire and take over as a going concern the business carried on at Liverpool and elsewhere by F. Bradley, and to carry on business as iron-founders, engineers, and manufacturers of cranes, winches, derricks, boilers, travellers, pumps, hoists, gears, tackle, castings, and other machinery and apparatus.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to August 5th, was filed on the 17th. The Company was registered on August 19, 1874, with a capital of £400,000, divided into 20,000 "A" and 20,000 "B" shares of £10 each. The capital was increased to £600,000, by special resolution passed November 20, 1888, by the addition of 20,000 new £10 shares. At the time of making up, all the shares were taken up, the full amount called, and all calls (£600,000) paid.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to August 2, 1892, was filed on the 8th following. The Company was registered on October 26, 1883, with a capital of £1,000,000, divided into 150,000 "A" and 50,000 "B" shares of £5 each. At the time of making up 89,261 £3 paid "A," 17,139 fully-paid "A", and 23,564 fully-paid "B" shares were taken up. 10s. per share has been called on the 89,261 £3 paid "A" shares, resulting in the payment of £44,630. 10s. The following sums have been considered as paid, viz.:—£223,152. 10s on the 89,261 £3 paid "A" shares, £85,695 on the 17,139 fully-paid "A" shares, and £117,820 on the 23,564 fully-paid "B" shares, making a total of £471,298 considered as paid.

UNITED RIVER PLATE TELEPHONE COMPANY (LIMITED.)—The annual return of this Company, made up to August 9th, was filed on the 15th. The Company was registered on December 17, 1886, with a capital of £500,000, in £5 shares. At the time of making up 58,000 shares were taken up, of which 16,000 were issued as fully paid. Upon the remaining 42,000 the full amounts have been called, and all calls (£210,000) paid.

CALLS DUE.—*Aug. 31st:* ISLINGTON AND GENERAL ELECTRIC SUPPLY (LIMITED), £1 per share. *Sept. 1st:* ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED), 10s. per share on 20,500 Perpetual £10 per Cent. Preference. *Sept. 5th:* JOHANNESBURG LIGHTING COMPANY (LIMITED), 25 per cent. (final call) on £7 per Cent. Mortgage Debenture Bonds.

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CITY NOTES, &c.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—In issuing the first annual report and balance-sheet of this Company, it is notified that a much fuller balance-sheet, made up to December 31st next, in the form prescribed by the Board of Trade, will be circulated by the Directors early in 1893. The first annual report will be found in our current issue.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 21st were £724, as against £728 for the corresponding period of last year, being a decrease of £4. The total receipts for half-year amount to £6,148, against £5,680 in the corresponding period of 1891, being an increase of £468.

NATIONAL TELEPHONE COMPANY (LIMITED).—The Stock Exchange Committee have ordered the further issue of £56,477 Four and a-Half Debenture Stock to be quoted in the official list.

NEW TELEPHONE COMPANY (LIMITED).—Application has been made to the Stock Exchange to appoint a settling day in, and to grant a quotation to, 48,000 ordinary shares of £10 each in this Company.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 19, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,603.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated receipts of this Company for the fortnight ended August 15, 1892, were £1,982, compared with £1,630 for 1891, showing an increase of £352.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 17.	Price Wednesday, Aug. 24.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 24. Highest.	Lowest.
			TELEGRAPHS			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	47 48	47 48	5 10 0	Jan., Apr., July, Oct.	46¾	..
£2,876,140	Stock	25/0	Do. Preferred	87½ 88½	87½ 88½	6 10 0	" "	88⅜	87½
£2,876,140	Stock	5/0	Do. Deferred	10½ 11	10½ 10¾	.. " "		10⅞	10½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 104	100 103	3 17 8	January and July ..	103	101⅜
130,000	£10	3/0	Brazilian Submarine	10½ 11	10¾ 11⅛	6 4 5	Mar., June, Oct., Dec.	11¼	10⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1⅜	Commercial Cable Capital Stock	160 165	160 165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	17½ 18½	17½ 18½	5 8 1	" "	17⅝	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3⅝	3¾ 3⅞	4 16 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States xd	11⅜ 11⅝	11⅜ 11⅝	6 0 2	Jan., Apr., July, Oct.	11⅛	11⅜
400,000	10	5/6	Eastern	14½ 15	14½ 15	4 6 8	" "	15	14½
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15¾	15½ 16	3 15 0	" "	15⅞	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	109 112	109 112	3 11 5	May and November	112	111½
£300,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15 15½	15 15½	4 12 7	Jan., Apr., July, Oct.	15½	..
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 9	February & August	110	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	103 106	3 15 16	February & August	103	..
180,227	10	3/0	Globe Telegraph and Trust	10 10½	10½ 10¾	4 12 4	Jan., Apr., July, Oct.	10⅝	10⅜
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	15½ 15⅝	3 17 5	" "	15⅞	15½
150,000	10	5/0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	107 110	107 110	4 10 11	March & September	..	..
17,000	25	1⅜	Indo-European	41 43	41 43	5 16 3	May and November	42½	42
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108 111	108 111	5 8 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October...	..	..
3,381	£100 Cert.	£1⅜	Submarine Cables Trust 6%..37/6 Bal. Ap. Coup.	115 120	115 120	5 0 0	" "	..	..
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101 104	101 104	4 16 2	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4 ..	..	January and July ..	3⅛	3⅜
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	..	..
88,321	10	6d.	West India and Panama	1 1½	1⅜ 1⅜ ..	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 9⅞	9¼ 9⅝	6 3 1	May and November	9½	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
64,242	15	6/0	Western and Brazilian	8¾ 9½	8¾ 9½	6 9 7	" "	8⅞	..
33,129	7½	1/3	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 7	" "	6¼	6¼
33,129	7½	4/6	Do. 5 per Cent. Deferred	2⅝ 3	2¾ 3¼ ..	..	" "	2⅝	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	103 106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	123 128	5 9 5	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	101	..
			TELEPHONES.						
£24,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
£20,000	£1	4½d.	Oriental (11s. paid)	1/16 ⅛	1/16 ⅛	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅛ 4⅜	4⅛ 4⅜	6 3 1	June and December	4⅛	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13¾ 14¼	13¾ 14¼	4 4 3	" "	14⅞	13¾
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13 13½	13 13½	4 8 11	" "	13⅞	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109 111	109 111	4 1 1	January and July ..	110½	109⅝
58,000	5	1/0	United River Plate	1 2	1 2 ..	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	—	..	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	—	City of London Electric Lighting (fully paid)	9⅞ 10½	9⅞ 10½	..	—	10⅜	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	—	—
8,332	£5	..	House to House Electric	2½ 3⅜	2½ 3½	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5½	5 5½	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 5⅝	5½ 5⅝	..	January and July ..	..	..
30,000	£5	4⅛%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16	3 7/16 3 9/16	..	March	..	..
10,000	£5	4⅛%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	..	March	—	—
111,000	5	..	London Electric Supply	⅜ 1⅜	⅜ 1⅜	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾ 7¼	6¾ 7¼	..	—	6¾	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5	4 5	..	—	..	—
18,680	£5	2/6	St. James' and Pall Mall	7½ 8	7½ 8	—	—	..	..
7,900	£5	7%	Do. 7% Preference	7¾ 8¼	8 8⅜ ..	..	—	8⅛	8
42,853	5	3%	Westminster Electric Supply (fully paid) xd	5¾ 6¼	5¾ 6¼	2 8 0	—	5⅞	5⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/9	Brush Electrical Engineering	2⅞ 3⅛	2⅞ 3⅛	..	..	3 1/16	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅝ 2⅞	2⅝ 2⅞	5 1 1	..	2¾	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares xd	5½ 6	5½ 5⅝	6 1 9	January and July ..	..	..
12,139	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	4⅞ 5¼	4⅞ 5¼	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2¼ 2⅝	2⅝ 2⅝	—	—	2⅝	2⅜
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha & c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22⅝	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	¼ ⅜	1/16 ¼	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3 3½	3 3½	11 0 0	May and November	3 1/16	3⅛
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	43 45	5 6 8	March and July....	43⅜	43½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½ ¾	½ ¾	..	—	..	..
—	£5	8%	Do. Preference (fully paid)	2½ 3	2½ 3	..	—	—	—
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	—	—	—
50,000	£10	½%	City and South London Railway xd	2½ 3½	2½ 3½	—	—	—	—

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THE ELECTRICIAN:

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NOTES.

One of the merits of the Physical Society of London, in the opinion of some of its members, has been the informality and conversational character of its meetings. The communications, though entitled "Papers," as is customary in scientific societies, have often been short discourses, sometimes without the assistance of any notes. Under these circumstances it has rested with the authors to take what steps they pleased about the publication of their contributions. Some of these have appeared in the columns of the technical journals, and others have never been heard of again. In our Notes will be found some resolutions which, while they impose certain restrictions, are not likely to lead to undue ceremony or vexatious stringency.

It is the very lack of such regulations or the inability of the committee to enforce them that detracts so much from the usefulness of the sectional meetings of the British Association, and thus an *olla podrida* of optics and dynamics leads to the state of things described by Prof. Ayrton in his letter to us this week. Not only has the Physical Society drawn up these excellent rules, but it has made definite arrangements for the publication of every Paper in full or in abstract, and we cannot doubt that the usefulness of the Society will be thus materially increased.

Slotted conduits in connection with mechanical propulsion on railways were well known long before Mr. Holroyd Smith designed his Blackpool line, and the idea of covering the slot by a movable iron strip was in use nearly half a century before Mr. Brain employed it. Fifty years ago considerable attention was being paid to pneumatic or atmospheric railways; the notion of one or two powerful stationary engines, and the absence of machinery on the trains were, no doubt, well appreciated. In 1843 a line about 1¾ miles in length was practically worked near Dublin, between Kingstown and Dalkey. Several very ingenious inventions by Murdoch and Medhurst were tried for keeping the slot air-tight. A hydraulic valve and a rope valve were used, but no great success was met until a line about five miles long was built between Croydon and Epsom by Clegg and Samuda. The conduit was 15in. in diameter, and air compressing engines of 300 H.P. were used. The cover strip did not lift clear of the slot as in the Brain system, described in another column, but consisted of a number of eight inch lengths, riveted to a steel band and to a leather strip hinged to one side of the slot. A mixture of beeswax and tallow was used to seal the joint, and the second car carried a charcoal heater to complete this operation. The leakage was said to be only one or two horse-power per mile, and a speed of over sixty miles an hour was attained. This mode of protecting a slotted conduit promises to be more useful in its application to electric traction than in its first appearance in connection with atmospheric railways.

The success which appears to have met the attempts of Captain De Khotinsky in the manufacture of glow lamps for high voltages raises once again the hope that the limits which have been reached by other makers are not so impassable as is generally supposed. Ten years ago it was said that electric lighting could barely pay at 100 volts, but that if lamps could be made which would run on circuits of 200 or 300 volts, economical supply would be assured. We cannot hope to alter the usual 100-volt standard for some time; but 200-volt lamps may find their way into use on three-wire systems, or where transformers are specially wound to suit them. Captain De Khotinsky's guarantee of his lamps is a bold departure from the common practice, but one which will, in all probability, be followed when competition becomes keen.

The apparent consequence of these high-pressure lamps, if we may use the term to imply lamps of high resistance for a given candle power, is the possibility of producing satisfactory lamps of 4 or 5 candle power for 100 volt circuits. At present, such lamps are hardly to be recommended, especially for the purposes for which they would be most useful, viz., the lighting of passages and stairs where light is required for long periods. In order to obtain a longer life for these small lamps it has been a common custom hitherto to place 102 volt lamps on 100 volt circuits, since these, running at a lower efficiency than usual, last about as long as an ordinary lamp.

The active part which the Post Office has taken in the establishment of telephonic communication, on both a large and a small scale, has been considered by many who have watched it to have been carried on for the purpose of experimenting with a system which might at no distant period or long notice be thrust upon that department. Whether such an extension of its duties is likely or no, the communication

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which is being established between coastguard stations and the other telephonic work on which the Post Office is already engaged is sufficient to warrant the issue of a carefully prepared circular from the office of the Engineer in-Chief for the instruction of the officers of the department. This circular, which, by permission, we are able to reproduce in another column, will be studied with interest by many of our readers who are concerned with the use or erection of private lines, and a very valuable feature of it is the full quantitative information given in the examples. In many respects the instructions set forth in this circular are a model of clearness, notably the figuring of the resistances of each section of the line on the diagrams, as enjoined in rule 15.

In the discussion on the proposal for a National Physical Laboratory, which we print in another column, it appeared that one of the topics that has been seriously investigated at the Berlin Reichsanstalt, is the production of a set of screw gauges suitable for fine mechanism, thus doing for the optical and instrument industries what WHITWORTH did for heavy engineering. The auxiliary establishment at Weimar, where 30,000 thermometers a year are sent to be standardised and certificated, was, it appears, carried out at the expense of the GRAND DUKE OF WEIMAR for the benefit of the neighbouring glass-working industries. Were it not that the British Association screw thread has, thanks to the London Chamber of Commerce, rendered any further action unnecessary, a department for screw gauges would be doubtless equipped at the expense of His Grace the DUKE OF BIRMINGHAM for the benefit of the neighbouring screw-making industries.

In a communication to the *Electrical Engineer* of New York Prof. CARHART states that the reason for the suppression of the one square millimetre cross-section, which has hitherto appeared in the specification of the mercury unit of resistance, was the discrepancy between the standard kilogramme and the cubic decimetre of water at 4° C. We called attention to the elaborate re-determination of the weight of a cubic inch of water by Mr. CHANEY in *The Electrician*, Vol. XXV., p. 633. A good deal of information on this subject is to be found in Mr. LATIMER CLARK'S valuable Dictionary of Metric Measures. He there points out that the litre weighs only 998·93 grammes, instead of 1,000, owing to the displacement of air, and that the kilogramme and therefore the litre is supposed to be heavier than the cubic decimetre of water in vacuo by about 120 milligrams, or 1·85 grains, owing to errors in the original determination. This error corresponds to a difference of $\frac{1}{2500}$ in the lineal measurement. Freedom from air was also neglected at this period. Thus the charming simplicity of the metric system, so dear to many minds, is spoiled; and instead of specifying the one square millimetre, the unit is described as 14·4521 grammes of mercury in the form of a column of uniform cross section, 106·3cm. in length at 0° C.

While a vast amount of work has been expended on the investigation of the temporary and reversible magnetisation exhibited by electromagnets, the permanent steel bar of the lecture-room and the red varnished horseshoe of the optician have continued to spread their lines of force unostentatiously and with an inflexible persistence, but have attracted the attention of few philosophers since the days of GILBERT. It is our duty, therefore, to present to our readers any further information that we can find on this subject. In yesterday's *Daily Telegraph* we found a leading article upon some experiments performed on various animals by treating them to the strains of the fiddle, the flute and the piccolo. In the case of deer, zebras, wild asses, and "even such notoriously unemotional creatures as the tapir and ostrich," this last instrument we are told "exercised upon them the sort of influence that is brought to bear upon a group of steel filings by the repellant pole of a powerful horse-shoe magnet. It dispersed them in all directions." This kind of magnet, though unfamiliar to most of our readers, seems to be quite in accordance and compatible with the peculiar kind of electric fluid about which our daily contemporaries, and this one in particular, occasionally discourse.

One of the many characteristics which differentiate American from English engineering practice is the transatlantic fondness for huge fly-wheels and enormous belts. In many instances we have in our ignorance been puzzled to discover a *raison d'être* for this custom. Perhaps the following paragraph from our engineering contemporary *Power*, which is but a sample of similar ones appearing almost weekly in the American technical papers, gives the clue; in the United States a fly-wheel is, as its name denotes, apparently intended to "fly":—

"Still another fly-wheel accident has wrecked the electric light station at Fostoria, Ohio, and killed the engineer. The engine, freed in some manner from the control of its governor, raced until its fly-wheel burst, killing Paul Hyder, the engineer, who had run to the throttle to shut down. The fly-wheel was 16ft. in diameter, and the largest fragment was only 4ft. in length, and was found in a loft, where it had struck the rafters and fallen back upon the joist. The fly-wheel of an engine in the temporary power house on the World's Fair grounds in Chicago flew to pieces a few weeks ago, but fortunately without fatal results."

Hove.—The laying of the underground electric light mains has commenced.

Kelvinside.—A meeting of the feuars in the Kelvinside district was held last week to protest against the erection of electric light works in that neighbourhood.

Personal.—We understand that Mr. Joseph A. Jeckell, who has been connected with the cable department of the London Electric Supply Corporation for the last four years, has been appointed electrician to the International Okonite Company.

Bradford.—The Gas and Electricity Supply Committee of the Corporation are making arrangements for the extension of the electricity works, as the demand for current is steadily growing. About seventeen miles of cable have now been laid down.

Exeter.—The process of changing the system of electric lighting from overhead wires to that of underground mains has been proceeding for the past seven weeks, and is expected to be completed in three weeks. The work is being done under contract by the Fowler-Waring Company.

Errata.—On page 447 of our last issue, in the article on "The British Association Conference on Electrical Standards," line 26 from bottom read, "cross-section of such a column," instead of "cross-section of a lens column." On page 448 read "ice" for "&c.," "Kreichgauer" for "Kreschgauer," and

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"manganin" for "magnesium." On page 466 the name of Prof. von Helmholtz's assistant should have been "Kreichgauer," and not "Dorn."

Specific Resistance of Peroxide of Lead.—In the course of some investigations carried out for the purpose of proving that, contrary to Streintz, electrolytically prepared lead peroxide *did* act as a metallic conductor, Mr. John Shields also approximately determined its specific resistance :—

Sp. resist. lead peroxide, chemically prepared ..... $5{\cdot}59 \times 10^9$ C.-G.-S.
Sp. resist. „ „ electrolytically „ ..... $6{\cdot}78 \times 10^9$ C.-G.-S.

No alteration was observed in these values on heating the peroxide up to 115°C.

Dundee.—The Finance Committee of the Dundee Gas Commissioners on Monday fixed the price of the electric light at 5d. per unit, being 1d. less than authorised by the Electric Lighting Order. The Secretary for Scotland has approved of the proposed borrowing for electric lighting purposes, the sinking fund being fixed to extend over 60 years. The works are expected to be completed by November.

The Chicago Exhibition.—The Exhibition buildings are to be dedicated on October 21st instead of the 12th. October 21st is the exact anniversary of Columbus's landing, allowance being made for the correction in the calendar made by Pope Gregory. ——The Electric Launch and Navigation Company of New York has been awarded the contract for running electric boats on the interior waterways at Jackson Park. It will pay the Exhibition 33⅓ per cent. of the gross receipts.

The West End Street Railway (Boston).—This Company now controls about 260 miles of track. During the past nine months the electric cars have run just on 5½ million miles, and their net earnings have amounted to $810,024, or 15 cents per car mile run. During the same period the horse cars have run 7¼ million miles, and have earned $367,036 net, or only 5 cents per mile run. In 1888 the operating expenses of the Company were 78·29 per cent. of the total receipts; in 1891 they were reduced to 74·48 per cent. Every year the earnings have been sufficient to pay the interest on the funded debt, 8 per cent. on the preferred stock, and 10 per cent. on all outstanding common stock.

Electrical Nomenclature.—One of the main points in coining names is harmony, says Mr. L. Gutmann in the *Electrical Engineer*, of New York, alluding to the advisability of introducing short words in place of such terms as "continuous-current generator," &c. The name "commutator" would, he thinks, have been the best for a continuous-current machine if it had not been adopted long ago for the mechanical device used as a portion of a continuous-current machine. The next best name seems to him to be "continuator," and similarly, "pulsator," so that we should have for the alternating-current dynamo, "alternator;" for the pulsatory current dynamo, "pulsator;" and for the continuous-current dynamo, "continuator."

Lightning Fatalities.—On Tuesday, 23rd ult., a sad fatality occurred at Stodmarsh, near Sandwich. Two men were standing at a doorway watching a storm when one of them was struck dead by lightning and the other badly injured. At Wickham, near Wingham, on the following day, a market gardener was talking to a labourer at the door of the latter, during the prevalence of a storm, and both were struck by lightning, the former fatally. During a violent thunderstorm on Wednesday last a shepherd was killed by lightning while tending his flock at Eglingham Quarry, a few miles from Alnwick. Lightning also struck Swansfield-house, Alnwick, the residence of the Duke of Northumberland's agent, demolishing a chimney and doing other damage.

Action at a Distance.—A correspondent of the *Standard* describes some *séances* given by a Madame Eusapia, in Italy. A long time ago this lady received an injury to the head, which has partially destroyed her sense of touch. Anent this, Prof. Lomoroso writes that he sees nothing inadmissible in the supposition that with hysterical or hypnotic subjects the excitation of certain centres should produce transmission of power. He admits that sensitiveness has left the body, but claims to have localised it in a zone not far removed from the body. His opinion is supported by that of Colonel de Rochas d'Aiglun, Administrator of the École Polytechnique, who, struck by the absence of feeling in catalytic patients, was led to investigate the subject. He says that, although the body of a hypnotic patient is directly insensible to pain, yet if the air be pinched at a few inches from the body the pinch will be felt. Sometimes the sensitive zone is several yards away. Here is a grand field for experiment, and a vast opening for new developments of "action at a distance."

The Physical Society of London.—The Council of this society has passed the following resolutions :—

1. That in future the rule that no Paper shall be read at a meeting of the Society until it has been reported on by a member of Council, shall be strictly observed. 2. That, when possible, proofs of the Papers to be read shall be printed and distributed to those persons who are likely to add to the interest of the discussions on them. 3. That special invitations shall be sent for any meeting to such persons, whether members of the Society or not. 4. That the secretaries shall note on each Paper the date on which it is received. 5. That the secretaries shall endeavour to obtain as many Physical Papers as possible in good time, so that they can be classified and Papers on similar or connected subjects can be read at each meeting.

Every Paper communicated to the Society is now published either in full or in abstract. If published in full it is published in the first instance in the "Philosophical Magazine," as communicated by the Society, and 100 copies of the Paper are sent to the author. Papers which have thus appeared in the "Philosophical Magazine" are afterwards reprinted in the "Proceedings" of the Society. Papers which the Council decide not to publish in full are published in abstract in the "Proceedings" of the Society.

The Magnetic Properties of Aluminum-Iron.—In a recent number of the Cornell *Crank* Mr. C. Eickemeyer details the results of some investigations as to the magnetic properties of aluminum-iron. A preliminary test showed that the magnetic properties of aluminum-iron differed so little from those of ordinary cast iron that it was necessary, in order to determine any difference whatever, to reduce the castings to standard size. The test was made by balancing the aluminum-iron with a test piece of Norway iron, the magnetic characteristic of which was known. The Al-Fe was not compared directly with the standard Norway iron, but to reach a greater exactness in determining the difference between ordinary cast iron and the samples of Al-Fe, first, a sample of ordinarily good cast iron was tested by comparing it with the standard Norway iron. The Al-Fe was then compared with this sample of ordinary cast iron and the difference between them determined. This method largely eliminated the influence of remanent magnetism in the comparative tests. In the comparisons made, the piece containing the smaller percentage of aluminum proved to be superior to the one containing the larger percentage of aluminum. From which it may be concluded that the addition of aluminum has no very marked influence upon the magnetic conductivity of cast iron, only slightly decreasing it.

A New Source of Revenue for Electric Traction Companies.—In October, 1891, the Capital Street Railway Company, of Little Rock, Ark., says the *Electrical World*, closed a contract with the Thomson-Houston Electric Company to equip the system with electricity. Some twenty 30 H.P. motor cars and six "trailers" are now in operation, and the line, with the following exception, offers no peculiarity. The power house is situated on the Arkansas River at a point midway between Little Rock and Big Rock, and overlooking the country for miles in either direction, and the Ozark Mountains on the north and west, it gives the most beautiful view that can be obtained in the city, which resulted in the designer providing for a summer theatre to be placed upon the roof. To those not familiar with the location of this plant, the idea of a theatre on the top of a power station may seem absurd, says our contemporary, but when it is remembered that the roof of this building has an area of over six-tenths of an acre, and is located about one hundred feet above the river, entirely removed from the noise of the machinery, and giving one of the most beautiful views that can be obtained in the Ozark Mountains, the idea may not seem so peculiar. Again, as the power station is located on the main line of the street railway, the theatre produces a source of revenue to the road that makes it quite an important factor.

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The Electrification of Steam Jets.—In December, 1890, Mr. Shelford Bidwell exhibited some striking experiments before the Physical Society on the electrification of steam jets. The image of a jet was thrown upon the screen, and was seen to be practically transparent. Upon the jet being electrified, however, the image immediately became dark and dense. Mr. Shelford Bidwell stated that he had examined the absorption spectrum of the jet, and that when unelectrified there was very little action, but that electrification caused a total disappearance of the violet. He concluded that the observed effects were due to electrification increasing the size of the water particles contained in the steam jet. In a Paper read before the Royal Society in March last Mr. John Aitken traverses this conclusion, and enumerates a large number of facts tending to show that the dense form of condensation is not due to an increase in the size of the drops, but to an increase in their number accompanied by a diminution in their size. Lord Rayleigh's experiment showing that it is only very feeble electrifications which cause water drops to coalesce, while strong electrifications have the diametrically opposite effect, is also cited in support of the author's contention. Mr. Aitken remarks that it has been generally stated that the effect of the electrification is sudden and marked. If, however, the discharging point is extremely fine, or if we assist the discharge by means of a flame, then we may begin with electricity of a very low potential, and the increase in the density of the jet may be made to begin by almost imperceptible degrees.

The San Salvatore Funicular Electric Railway.—There is an electrical funicular line running up the peak of San Salvatore, the summit of which is some 2,000ft. above Lugano. The line consists of a single track one mile long, and is on the Abt system. The average gradient on the lower half is 28 per cent., and on the upper portion 50 per cent. One 48-passenger car ascends, while another descends, the two cars meeting at the middle of the line, where the passengers change over. The generating station is at Maroggia, some 840ft. below a reservoir, which is fed through a pipe at the rate of 55 gallons a second, from a stream 3 miles off. Only a portion of the available power is at present utilised. A 250 H.P. horizontal Girard turbine is coupled direct to two 100 H.P. 2,000 volt lighting alternators, supplying current to Lugano; and a 125 H.P. turbine drives a 60 H.P. 1,800 volt generator. The field-magnet coils of this generator are automatically short-circuited when the current on the line increases beyond a certain amount. The line connecting Maroggia with San Salvatore hauling-house is 4½ miles long, and consists of 5mm. copper wire carried on Johnson and Phillips' oil insulators. The conductors are protected from lightning by a barbed-iron wire, which runs above them, and is connected to earth. At the San Salvatore works, the hauling-drum is driven by a 50 H.P. compound-wound motor running at 700 revolutions. The motor is belted to countershafting, from which the drum is driven by bevil wheels. A steam-engine is held in reserve. The installation was carried out by the Oerlikon Works.

An Invitation to Exhibit.—Advices from England seem to indicate an apathy in that quarter in regard to the World's Fair that is difficult for us (*Electricity*, of New York) to understand. The manufacturers of agricultural implements have about decided to make no exhibit. This we can readily understand, for the United States is so far in advance of all other countries in this branch of manufacture that for Great Britain to exhibit in this class would be but to advertise her own incompetency. The steam-engine makers have also decided to hold aloof, and we are not so much surprised at this, for it is our opinion that we lead the world in this direction also. And now *The Electrician* editorially remarks, on July 15th, "but it is not improbable that many dynamo makers agree with the steam-engine makers as to the policy of not exhibiting at all." At first blush we were inclined to think *The Electrician*, which has never been favourable to the World's Fair, was expressing its wish rather than the facts, but on looking more closely into the matter we find that the prospect of a good Electrical exhibit from Great Britain is at present exceedingly slim. . . . *The Electrician* has all along been howling about the tariff as an invitation to keep away, but the nonsense of this has been clearly pointed out from time to time by Mr. Dredge, Mr. Preece and others. It is possible that things may take a more favourable turn ere long, and Mr. Preece is bending all his energies to bring this about; but if the turn does not come, Great Britain will advertise her inability to compete with other civilised countries in terms so unmistakable that it will be difficult for her to explain the matter away.

The Indian Telegraph System.—During the year 1890-91 the line mileage of the Indian telegraph system increased by 5 per cent., the total now being 37,000 miles. The total number of telegraph offices now open is 3,103, as against 2,935 in 1889-90. Private telegrams increased 8 per cent. during 1890-91, and now stand at nearly three millions; receipts, however, only increased by a trifle over 1 per cent. The Administration continues to purchase old railway rails, and to make telegraph poles out of them, and in the twelve months under consideration purchased 19,000 for that purpose. Four cables were laid across the River Irrawaddy, near Ava, three across the Hooghley, two across the Rudda, and one across the Bassein (Burmah). In Burmah and Assam some 200 miles of line were constructed for strategical purposes, mostly under great difficulties. The rebellion in Manipur in March, 1891, naturally resulted in the complete destruction of the line running through that state, which was, however, soon restored. During the twelve months under consideration the average duration of the line interruptions was 23 hours, as against 21 hours for the previous year, and the number was 1,473 as against 1,389; an increase due chiefly to inundations in Upper Burmah. Some 48 interruptions were caused by lightning, and 110 by birds and other animals. Interruptions due to "malevolence" are on the increase. At Moulmein rats caused a two days' interruption by their consumption of the gutta-percha of a cable; and at the same place two interruptions, lasting respectively 21 and 26 hours, were brought about by white ants getting mixed up with the lightning protectors. In Upper Burmah wild elephants were responsible for three interruptions, lasting in all 201 hours.

A Pacific Cable Survey.—The following facts elicited by the latest U.S. survey of the ocean bottom between San Francisco and Honolulu are given by the *Western Electrician*:—The "Thetis," says our Chicago contemporary, left San Francisco on April 18th last to take soundings over the proposed route from California to the Sandwich Islands, the first section of a proposed cable route to Japan. Six months ago the "Albatross" made a similar survey, but the results attained at that time were not considered of a nature very favourable to the project. The "Albatross" surveyed a route running from a point on Monterey Bay direct to Honolulu. Her soundings showed that the bottom of the sea was very irregular over the greater part of the route surveyed. The depths were considerable, and a great many lofty coral reefs were discovered along the track. The "Thetis" started from Point Conception, 220 miles south of San Francisco. This place is considered by electricians to be favourable for a deep-sea cable landing. The "Thetis" took a course nearly due south-west, and by way of the Great Circle. At the beginning soundings were made every two miles until a depth of 900 fathoms was registered. Five miles out from Point Conception bottom was found at 87 fathoms, and at 13 miles 281 fathoms were registered. From that point onwards the depth increased gradually to 3,000 fathoms. That was the average for many miles. When the bottom was level soundings were taken every 10 miles, and where it was irregular, undulating, or where reefs were discovered, soundings were taken at short intervals down to two in a mile. The greatest depth sounded on the route was 3,228 fathoms, at a point about 300 miles from Hilo, on the island of Hawaii, where it is proposed to land the cable. The water shoaled to 1,000 fathoms 35 miles from Hilo, and shoaled gradually from that on to the landing place, near which the depth is 20 fathoms. For the route surveyed by the "Thetis" the cable to the Sandwich Islands would be 2,060 miles in length. The route surveyed by the "Albatross" was about 50 miles longer. The approximate distances of each route are:—British Columbia to Japan, 3,600 miles; San Francisco to Japan, 5,900 miles; British Columbia to Australia, 6,750 miles.

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ELECTROMAGNETIC THEORY.—XXXV.

BY OLIVER HEAVISIDE.

(*Continued from page 356.*)

§ 160. Linear vector functions of a vector play a very important part in vector-algebra and analysis, just as simple equations do in common algebra. Thus, in the theory of elasticity the strain vector is a linear function of the direction vector, and the stress vector is another linear function of the direction vector. In electromagnetism the electric displacement is a linear function of the electric force, and so is the conduction current-density; whilst the magnetic induction is a linear function of the magnetic force, when its range is small enough. There are, therefore, at least five examples of linear vector functions to be considered in electromagnetism. In other sciences too the linear function often turns up, and frequently in pure geometry, when treated algebraically. Finite rotations may be treated by the method, and in the algebra of surfaces of the second order the linear connection between two vectors is prominent. It would be inexcusable not to give some account of linear operators in this chapter on vector-analysis and its application to electromagnetism. The subject, however, is such a large one that it is only possible to deal with its more elementary parts in a somewhat brief manner—not, however, so brief as to be useless.

The simplest kind of linear connection is that of Ohm's law in isotropic conductors. We have $C = kE$, where E is the intensity of electric force and C the current-density, whilst k is a constant, the conductivity. No specification of direction is here made. But when vectorised, we have the equation $\mathbf{C} = k\mathbf{E}$ instead, k being as before. We now assert that **E** and **C** are parallel, whilst their tensors are in a constant ratio, for all directions in space.

Suppose, however, we alter the conductivity of the body in a certain direction, say that of **i** (*e.g.*, by means of compression parallel to **i**), making it k_1, whilst its conductivity is k_2 in all directions transverse to **i**. We now have $C_1 = k_1E_1$, and $\mathbf{C}_1 = k_1\mathbf{E}_1$, when the electric force is parallel to **i**. But if it be transverse to **i**, then we have $\mathbf{C} = k_2\mathbf{E}$. There is, in both cases, parallelism of **E** and **C**, but the ratio of the tensors differs in the two cases. What, then, is the current when **E** is neither parallel nor transverse to **i**? The answer is to be obtained by decomposing **E** into two components, one parallel to **i**, the other transverse; then reckoning the currents to match by the above, and finally combining them by addition. Thus

$$\mathbf{C} = \mathbf{i}.k_1E_1 + \mathbf{j}.k_2E_2 + \mathbf{k}.k_2E_3, \quad . \quad . \quad . \quad (1)$$

where E_1, E_2, E_3 are the **i**, **j**, **k** scalar components of **E**. We have here made use of the linear principle. It is that the sum of the currents due to any two electric forces is the current due to the sum of the electric forces. This principle (suitably expressed) applies in all cases of linear connection between two vectors, and is the ultimate source of the simplicity of treatment that arises.

More generally, let the conductivity be different in the three co-perpendicular directions of **i**, **j**, **k**, being k_1, k_2, k_3 respectively. Then we have

$$\mathbf{C} = k\mathbf{E} = \mathbf{i}.k_1E_1 + \mathbf{j}.k_2E_2 + \mathbf{k}.k_3E_3. \quad . \quad . \quad . \quad (2)$$

The current is now coincident with the electric force in three directions only, namely, along the principal axes of conductivity. When **E** has any other direction than that of a principal axis, we have no longer parallelism of **C** and **E**, and their relation is expressed by equation (2). It is the general type of all linear relations of the symmetrical kind when referred to the principal axes, if we remove the restriction which obtains in the electrical example that the k's must be all positive. Given, then, that $\mathbf{C} = k\mathbf{E}$, with the understanding that **C** is a symmetrical linear function of **E**, so that k must represent the linear operator connecting them (the conductivity operator in the above example) the full answer to the question, What is the **C** corresponding to a given $\mathbf{E}^2$ is obtainable in the above manner, viz., by first finding the axes of parallelism of **E** and **C** and the values of the principal k's, and next, by adding together the three **C**'s belonging to the three component **E**'s parallel to the axes.

The inverse question, given **E** find **C**, is similarly answerable. For if $\mathbf{C} = \rho\mathbf{E}$, where ρ is the operator inverse to k (or the resistivity operator in the case of conduction-current), we know that $k_1\rho_1 = 1$, if ρ_1 is the constant resistivity parallel to **i**, and similarly $k_2\rho_2 = 1$ and $k_3\rho_3 = 1$ for the **j** and **k** axes, so that in full,

$$\mathbf{E} = \rho\mathbf{C} = \mathbf{i}.\rho_1C_1 + \mathbf{j}.\rho_2C_2 + \mathbf{k}.\rho_3C_3, \quad . \quad . \quad . \quad (3)$$

where C_1, C_2, C_3 are the scalar components of current.

Precisely similar remarks apply to the permittivity operator c in $\mathbf{D} = c\mathbf{E}$ connecting the displacement **D** with the electric force **E**, and to the inductivity operator μ in $\mathbf{B} = \mu\mathbf{H}$, connecting the induction **B** with the magnetic force **H**, when the connection is a linear one. It is not without importance to constantly bear in mind the above process of passing from **E** to **C** through k, and the process of inverting k to ρ, because when treated in a general manner, with reference to any axes, the relations become much more complicated, whilst their intrinsic and resultant meaning is identically the same.

§ 161. Next let us obtain some geometrical illustrations of the previous. The transition from **E** to **C** is like that from a sphere to an ellipsoid. If a solid be uniformly subjected to what is termed a homogeneous strain, any initially spherical portion of it becomes an ellipsoid. If this be done without rotation, the state is such that all lines parallel to a certain axis, say that of **i**, in the unstrained solid are lengthened or shortened in a certain ratio in passing to the strained state, without change of direction. The same is true as regards lines parallel to two other axes, say **j** and **k**, perpendicular to each other and to the first axis. The ratio of lengthening or shortening is generally different in the three directions of preservation of parallelism.

The equation of the ellipsoidal surface itself is

$$1 = \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2}, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

when referred to the centre and the principal axes. Here a, b, c, are the lengths of the principal semi-axes, whilst x, y, z, are the scalar components of **r**, the radius vector from the centre to any point of the surface. It may be written

$$1 = \left(\mathbf{i}\frac{x}{a} + \mathbf{j}\frac{y}{b} + \mathbf{k}\frac{z}{c}\right)^2 = \mathbf{N}^2 \text{ say}, \quad . \quad . \quad (5)$$

from which we see that when **r** belongs to the ellipsoid, **N** is a unit vector, the vector radius of a certain sphere from which the ellipsoid **r** may be obtained by homogeneous strain, the three ratios of elongation being a, b, c (that is, the co-ordinate x/a in the sphere become x in the ellipsoid, and so on).

Now, if we square (3) and divide by $\mathbf{E}^2$, we may write it

$$1 = \frac{C_1^2}{(k_1E)^2} + \frac{C_2^2}{(k_2E)^2} + \frac{C_3^2}{(k_3E)^2}, \quad . \quad . \quad . \quad . \quad (6)$$

where the C's are the components of **C**, and E is the tensor of **E**. Now suppose E is constant, and let **E** take all directions in succession. Its extremity will range over a spherical surface. Now the end of the corresponding **C** or $k\mathbf{E}$ will range over an ellipsoidal surface. For we may take k_1E, k_2E, k_3E in (6) to be a, b, c in (4); when C_1, C_2, C_3 will simultaneously be x, y, z. The semi-axes of this current-ellipsoid are the principal currents in the directions of parallelism of electric force and current.

Similarly to (6), we have, by squaring (2),

$$1 = \frac{E_1^2}{(\rho_1C)^2} + \frac{E_2^2}{(\rho_2C)^2} + \frac{E_3^2}{(\rho_3C)^2}, \quad . \quad . \quad . \quad . \quad (7)$$

from which we see that when C is constant, so that the vector **C** ranges over a spherical surface, the corresponding **E** simultaneously ranges over the surface of an ellipsoid whose principal semi-axes are the principal E's.

There are other ways of illustration than the above. Thus we may see from the form of the right number of (4) that it is the scalar product of **r** and another vector **s**, thus

$$\mathbf{rs} = 1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where **r** and **s** are given by

$$\mathbf{r} = \mathbf{i}x + \mathbf{j}y + \mathbf{k}z, \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$\mathbf{s} = \mathbf{i}\frac{x}{a^2} + \mathbf{j}\frac{y}{b^2} + \mathbf{k}\frac{z}{c^2} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

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Here we see that $\mathbf{s}$ is a linear function of $\mathbf{r}$, and such that if $\mathbf{N}=\phi\mathbf{r}$, then $\mathbf{s}=\phi\mathbf{N}=\phi\phi\mathbf{r}=\phi^2\mathbf{r}$. See equation (5). The interpretation of the new vector $\mathbf{s}$ is easily to be found. It is the reciprocal of the vector perpendicular from the centre upon the tangent plane to the ellipsoid at the extremity of $\mathbf{r}$. For if $\mathbf{p}$ be this perpendicular, the projection of $\mathbf{r}$ upon $\mathbf{p}$ is evidently $\mathbf{p}$ itself, because the three vectors $\mathbf{r}$, $\mathbf{p}$, and the line in the tangent plane joining their extremities form a right-angled triangle whose longest side is $\mathbf{r}$. Therefore

$$\mathbf{rp}=\mathbf{p}^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

or, dividing by $\mathbf{p}^2$,

$$\mathbf{rp}^{-1}=1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

comparing which with (8), which is true for all $\mathbf{r}$'s of the ellipsoid, we see that $\mathbf{s}=\mathbf{p}^{-1}$, as stated.

Now we have

$$\frac{\mathbf{EC}}{\mathbf{EC}}=1\,\frac{\mathrm{E}_1^2}{\rho_1\mathbf{EC}}+\frac{\mathrm{E}_2^2}{\rho_2\mathbf{EC}}+\frac{\mathrm{E}_3^2}{\rho_3\mathbf{EC}}, \quad . \quad . \quad . \quad (13)$$

from which we see that if we construct the ellipsoid whose principal semi-axes are $(\rho_1\mathbf{EC})^{\frac{1}{2}}$, and so on, the radius vector will be $\mathbf{E}$ and the corresponding reciprocal perpendicular will be $\mathbf{C}/\mathbf{EC}$. Here $\mathbf{EC}$ is understood to be constant.

Similarly, we have

$$1=\frac{\mathrm{C}_1^2}{k_1\mathbf{EC}}+\frac{\mathrm{C}_2^2}{k_2\mathbf{EC}}+\frac{\mathrm{C}^2{}_3}{k_3\mathbf{EC}}, \quad . \quad . \quad . \quad . \quad (14)$$

so that in the ellipsoid with principal semi-axes $(k_1\mathbf{EC})^{\frac{1}{2}}$, &c., the radius vector is $\mathbf{C}$ and the reciprocal perpendicular is $\mathbf{E}/\mathbf{EC}$. In both these methods of representation neither $\mathbf{E}$ nor $\mathbf{C}$ has constant tensor, but their product, the activity, is constant.

In the case (6), where it is E that is considered constant, the reciprocal of the perpendicular on the tangent plane to the ellipsoid of $\mathbf{C}$ is

$$\frac{\mathrm{iC}_1}{(k_1\mathrm{E})^2}+\ldots=\frac{\mathrm{i}\rho_1\mathrm{E}_1}{\mathrm{E}^2}+\ldots=\frac{\rho\mathbf{E}}{\mathrm{E}^2}. \quad . \quad . \quad . \quad . \quad (15)$$

This is also an ellipsoid. For $k\mathbf{E}$ is an ellipsoid, and $\rho\mathbf{E}$ only differs in the principal constants being the reciprocals of those in the former case.

Similarly, in the case (7), where C is constant, the reciprocal perpendicular is

$$\frac{\mathrm{iE}_1}{(\rho_1\mathrm{C})^2}+\ldots=\frac{\mathrm{i}k_1\mathrm{C}_1}{\mathrm{C}^2}+\ldots=\frac{k\mathbf{C}}{\mathrm{C}^2}, \quad . \quad . \quad . \quad (16)$$

and again the extremity of $k\mathbf{C}$ ranges over an ellipsoidal surface.

Thus the sphere of $\mathbf{E}$ with constant tensor is associated with an ellipsoid $k\mathbf{E}$, whose reciprocal perpendicular is $\rho\mathbf{E}/\mathrm{E}^2$ or $k^{-1}\mathbf{E}/\mathrm{E}^2$, another ellipsoid. It follows that the reciprocal perpendicular of the latter gives us the former ellipsoid again, or the same with radius vectors altered in a fixed ratio.

This reciprocal relation of two ellipsoids through their inverse perpendiculars is an example of Maccullagh's extraordinary theorem of reciprocal surfaces. It may be stated thus. Let

$$\mathbf{r}_1\mathbf{s}_1=1, \quad \text{and} \quad \mathbf{r}_2\mathbf{s}_2=1, \quad . \quad . \quad . \quad . \quad (17)$$

be the equations of two surfaces referred to the same origin, $\mathbf{r}_1$ and $\mathbf{r}_2$ being the radius vectors, and $\mathbf{s}_1$, $\mathbf{s}_2$ the reciprocals of the vector perpendiculars from the origin on their tangent planes. If, then, we choose $\mathbf{r}_2$ to be $\mathbf{s}_1$, we shall simultaneously make $\mathbf{s}_2$ be $\mathbf{r}_1$. That is, starting with the surface $\mathbf{r}_1$, construct the surface whose radius vector $\mathbf{r}_2$ is $\mathbf{s}_1$, the reciprocal perpendicular of the $\mathbf{r}_1$ surface. Then the reciprocal perpendicular $\mathbf{s}_2$ of the second surface ($\mathbf{s}_1$ or $\mathbf{r}_2$) will be the radius vector $\mathbf{r}_1$ of the first surface.

This admits of simple vectorial proof. For if $\mathbf{r}_1\mathbf{s}_1=1$ be the equation of a surface according to the above notation, we obtain, by differentiation,

$$\mathbf{r}_1 d\mathbf{s}_1+\mathbf{s}_1 d\mathbf{r}_1=0, \quad . \quad . \quad . \quad . \quad , \quad (18)$$

if $d\mathbf{r}_1$ and $d\mathbf{s}_1$ are simultaneous variations of $\mathbf{r}_1$ and $\mathbf{s}_1$. But $d\mathbf{r}_1$ is in the tangent plane to $\mathbf{r}_1$, and therefore at right angles to $\mathbf{s}_1$, so that $\mathbf{s}_1 d\mathbf{r}_1=0$. This leaves $\mathbf{r}_1 d\mathbf{s}_1=0$ also. But $d\mathbf{s}_1$ or $d\mathbf{r}_2$ equivalently is in the tangent plane of the surface whose vector radius is $\mathbf{s}_1$, or $\mathbf{r}_2$; therefore $\mathbf{r}_1$ is parallel to the perpendicular on the same, or parallel to $\mathbf{s}_2$, say, $\mathbf{r}_1=x\mathbf{s}_2$, from which $\mathbf{r}_1\mathbf{s}_1=x\mathbf{s}_1\mathbf{s}_2$ or $x\mathbf{r}_2\mathbf{s}_2$. But $\mathbf{r}_1\mathbf{s}_1=1$ and $\mathbf{r}_2\mathbf{s}_2=1$, so $x=1$, and $\mathbf{r}_1=\mathbf{s}_2$, which completes the connections.

In terms of the perpendiculars, let p_1 and p_2 be their lengths and r_1, r_2 the corresponding radius vectors, then

$$r_1 : r_2 = p_1 : p_2, \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

and $\mathbf{r}_1$ is parallel to $\mathbf{p}_2$, and $\mathbf{r}_2$ to $\mathbf{p}_1$.

§ 162. Leaving now the geometrical illustrations connected with the ellipsoid, consider the symmetrical linear operator by itself. If $\mathbf{D}=c\mathbf{E}$, where c is the linear operator, we know by the above exactly how it operates through the principal c's. We can, however, write c in such a manner that it shall state explicitly its meaning. Thus, if c_1, c_2, c_3 be the principal c's belonging to the axes of $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$, we have

$$c\mathbf{E}=\mathbf{i}.c_1\mathrm{E}_1+\mathbf{j}.c_2\mathrm{E}_2+\mathbf{k}.c_3\mathrm{E}_3, \quad . \quad . \quad . \quad (20)$$

by § 160. Now put the E's in terms of $\mathbf{E}$, producing

$$c\mathbf{E}=\mathbf{i}.c_1\mathbf{i}\mathbf{E}+\mathbf{j}.c_2\mathbf{j}\mathbf{E}+\mathbf{k}.c_3\mathbf{k}\mathbf{E}. \quad . \quad . \quad . \quad (21)$$

In this form, the operand may be separated from the operator, thus

$$c\mathbf{E}=(\mathbf{i}.c_1\mathbf{i}+\mathbf{j}.c_2\mathbf{j}+\mathbf{k}.c_3\mathbf{k})\mathbf{E}, \quad . \quad . \quad . \quad (22)$$

so that the expression for c itself is

$$c=\mathbf{i}.c_1\mathbf{i}+\mathbf{j}.c_2\mathbf{j}+\mathbf{k}.c_3\mathbf{k}. \quad . \quad . \quad . \quad . \quad (23)$$

In this form, with a vector to operate upon implied, the nature of c is fully exhibited. But the operand need not follow the operator. If it precedes it the result is just the same. Thus by (23),

$$\mathbf{E}c=\mathbf{E}\mathbf{i}.c_1\mathbf{i}+\mathbf{E}\mathbf{j}.c_2\mathbf{j}+\mathbf{E}\mathbf{k}.c_3\mathbf{k}$$
$$=c_1\mathrm{E}_1.\mathbf{i}+c_2\mathrm{E}_2.\mathbf{j}+c_3\mathrm{E}_3.\mathbf{k}=c\mathbf{E}. \quad . \quad . \quad (24)$$

When, however, the operator is unsymmetrical, the vectors $c\mathbf{E}$ and $\mathbf{E}c$ are not identical. They are said to be conjugate to one another, so that in the symmetrical case of identity, c is also called a self-conjugate operator. The distinction between symmetrical and skew operators will appear later.

There are six vectors concerned in c, viz., $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$, and $c_1\mathbf{i}$, $c_2\mathbf{j}$, $c_3\mathbf{k}$, which call $\mathbf{I}$, $\mathbf{J}$, $\mathbf{K}$. Thus

$$c=\mathbf{i}.\mathbf{I}+\mathbf{j}.\mathbf{J}+\mathbf{k}.\mathbf{K} \quad . \quad . \quad . \quad . \quad . \quad (25)$$

is the type of a symmetrical operator referred to the principal axes. Now the general form of c referred to any axes and with the symmetrical restriction removed is obtained by turning these six vectors to any six others; thus,

$$\phi=\mathbf{a}.\mathbf{l}+\mathbf{b}.\mathbf{m}+\mathbf{c}.\mathbf{n}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

so that

$$\phi\mathbf{E}=\mathbf{a}.\mathbf{l}\mathbf{E}+\mathbf{b}.\mathbf{m}\mathbf{E}+\mathbf{c}.\mathbf{n}\mathbf{E}, \quad . \quad . \quad . \quad . \quad . \quad (27)$$

$$\mathbf{E}\phi=\mathbf{E}\mathbf{a}.\mathbf{l}+\mathbf{E}\mathbf{b}.\mathbf{m}+\mathbf{E}\mathbf{c}.\mathbf{n}, \quad . \quad . \quad . \quad . \quad . \quad (28)$$

show the linear function and its conjugate explicitly. This is (with a changed notation, however), Prof. Gibbs's way of regarding linear operators. The arrangement of vectors in (26) he terms a dyadic, each term of two paired vectors ($\mathbf{a}.\mathbf{l}$) being a dyad. Prof. Gibbs has considerably developed the theory of dyadics.

Returning to the simpler form (25) or (22), we may note the effect of the performance of the operation symbolised by c a number of times, directly or inversely. Thus by (22) or (21), or (20), we have

$$\left.\begin{aligned} c^2\mathbf{E}&=cc\mathbf{E}=\mathbf{i}.c_1{}^2\mathrm{E}_1+\mathbf{j}.c_2{}^2\mathrm{E}_2+\mathbf{k}.c_3{}^2\mathrm{E}_3,\\ c^3\mathbf{E}&=cc^2\mathbf{E}=\mathbf{i}.c_1{}^3\mathrm{E}_1+\mathbf{j}.c_2{}^3\mathrm{E}_2+\mathbf{k}.c_3{}^3\mathrm{E}_3,\\ c^{-1}\mathbf{E}&=\mathbf{i}.\frac{\mathrm{E}_1}{c_1}+\mathbf{j}.\frac{\mathrm{E}_2}{c_2}+\mathbf{k}.\frac{\mathrm{E}_3}{c_3}, \end{aligned}\right\} \quad . \quad . \quad (29)$$

and so on. Thus c^n means the operator whose principals are the nth powers of those of the primitive c, with the same axes. We therefore get a succession of ellipsoids with similarly directed principal axes, only altering their lengths, when the initial $\mathbf{E}$ has a constant tensor. (That is, provided the principal c's are all positive. If some be negative, we have other surfaces of the second order to consider.)

We may also manipulate in the same simple manner any number of operators, a, b, c, &c., which have the same principal axes, though they may differ in other respects. Thus, using the same kind of notation,

$$\left.\begin{aligned} a\mathbf{E}&=\mathbf{i}.a_1\mathrm{E}_1+\mathbf{j}.a_2\mathrm{E}_2+\mathbf{k}.a_3\mathrm{E}_3,\\ ba\mathbf{E}&=ab\mathbf{E}=\mathbf{i}.a_1b_1\mathrm{E}_1+\mathbf{j}.a_2b_2\mathrm{E}_2+\mathbf{k}.a_3b_3\mathrm{E}_3,\\ cba\mathbf{E}&=abc\mathbf{E}=\mathbf{i}.a_1b_1c_1\mathrm{E}_1+\mathbf{j}.a_2b_2c_2\mathrm{E}_2+\mathbf{k}.a_3b_3c_3\mathrm{E}_3, \end{aligned}\right\} \quad . \quad (30)$$

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and so on. That is, the successive action of any number of symmetrical operators with common principal axes is equivalent to the action of a single operator of the same kind, whose principals are the products of the similar principals of the set of operators. The resulting ellipsoids have their axes parallel throughout. Next, multiply the equation (20) by any other vector **F**, producing

$$\mathbf{F}c\mathbf{E} = c_1E_1F_1 + c_2E_2F_2 + c_3E_3F_3. \quad . \quad . \quad . \quad (31)$$

By symmetry we see that this is identically the same as **E**c**F**. We might also conclude this from the fact that c**E** and **E**c are the same vector; or, thirdly, by forming c**F**, and then multiplying it by **E**. We may therefore regard **E**c**F** as the scalar product of **E** and c**F** (or **F**c), or, as the equal scalar product of **E**c (or c**E**) and **F**. This reciprocity is the general characteristic of symmetrical operators, by which they can be distinguished from the skew operators. The electrical meaning in terms of displacement and electric force is that the component displacement in any direction **N**, due to an electric force acting in any other direction **M**, equals the component displacement along **M**, due to the same electric force along **N**.

(To be continued.)

DUBLIN CENTRAL ELECTRIC LIGHTING STATION.

In November, 1890, a special committee of the Dublin Corporation selected the tender of the Electrical Engineering Company of Ireland for the electric lighting of Dublin, but a strong minority of the Corporation were in favour of the Irish House-to-House Electricity Company, and a compromise was eventually effected, and it was decided on February 11, 1891, to give the contract to the Electrical Engineering Company of Ireland on the assurance that they would have the assistance of the Irish House-to-House Company in the execution of the contract. It is hardly necessary to remind our readers that the Electrical Engineering Company of Ireland is a branch of the Brush Electrical Engineering Company, and the Irish House-to-House Electricity Company is associated with Messrs. Hammond & Co.

The central electric lighting station which has just been erected for the Dublin Corporation is centrally situated in Fleet-street, at the rear of the old Parliament Houses. Here are erected the three sets of the two kinds of plants, viz., the Lowrie-Parker high tension alternating current system for supplying current to consumers' houses, and a continuous current Brush system for lighting the streets by means of arc lamps. For the private lighting there are three pairs of compound horizontal non-condensing engines, of 280 H.P. each, working at a pressure of 140lb. per square in. in the steam chests, and running at a speed of 85 revolutions per minute. The admission and exhaust of the steam is regulated by the well-known patent Corliss valve system. The fly-wheels, weighing nearly 10 tons each, are 14ft. in diameter, and are grooved for 12 cotton ropes running direct to the dynamos. The engines are of Irish make, being specially built by Messrs. Coates and Co., of Belfast. There are two main ranges of steam pipes and one range of exhaust piping, the latter running from the low-pressure cylinders of the engines to the feed-water heaters, which are erected at one end of the boiler house. The engine foundations are built of concrete and granite blocks from a depth of 16ft. where the solid rock was reached.

Coupled direct by 12 1½in. cotton ropes to the engines are the Lowrie-Parker alternating-current dynamos, each giving an output of 75 amperes at 2,000 volts—or, in other words, each machine is capable of supplying current to 5,600 lamps of 8 c.p. Their speed is 350 revolutions per minute. The speed at which the armature conductor is passed by the field-magnets is about 6,000ft. per minute, giving a frequency of about 83 complete periods per second. All three machines are identical. The armature conductor coils are formed of narrow copper tape, each wound in a plane upon a piece of insulating material of the same thickness as the width of the tape, and rounded at the ends. These coils are placed close together upon the cylindrical inner surface of the armature ring. The armature coils are easily removed or replaced as required, and this remark applies likewise to the magnet windings. The armature ring is divided on the horizontal line, so that the upper half is removable for inspection or repairs. The moving part of the machine consists of a solid, soft wrought-iron ring, with pole-pieces securely attached thereto, and is arranged so that the centrifugal force of the whole of the moving parts is taken by the ring.

The bearings are 20in. long; they are in halves, jointed on the horizontal centre and fitted with loose brasses of phosphor bronze, top and bottom. The bottom brass is so arranged that it can be removed without lifting the shaft.

The exciter is a series-wound machine, with drum armature running at a speed of 800 revolutions. We are not in possession of any information about the output.

At the opposite end of the room are situated the three arc lighting sets supplied by the Brush Electrical Engineering Company, comprising three vertical compound Raworth engines and three continuous-current Brush dynamos. The engines are 60 H.P., and run at a speed of 220 revolutions per minute. The low pressure cylinder is fitted with automatic relief valves. The fly-wheels are 8ft. in diameter and grooved for 8 cotton ropes, thus coupling the engines direct with the dynamos, which have an output of 10 amperes at 3,000 volts. The speed of the dynamos is 800 revolutions per minute. The armatures are of laminated iron, wound with coils in twelve recesses, the opposite coils being connected in series, the free ends being brought out through the shaft, which is hollow, to the plates of the commutator in the usual way. A travelling crane capable of lifting 10 tons is erected in the engine-room, and is used for moving and erecting the heavy portions of the machinery.

The steam-generating plant is composed of four Babcock and Wilcox water-tube boilers, each capable of evaporating 8,500lb. of water per hour at a pressure of 150lb. per square inch. The total heating surface in each boiler is 51sq. ft. They are set in two batteries of two boilers each, each battery being provided with a steam receiver having outlets for the connections to the main ranges of steam pipes. The steam and water drums are 36in. in diameter and 33ft. 7in. long, made of steel ⅜in. thick.

Close to the boilers are three Worthington Steam Pumps, each capable of supplying water to two boilers when fully loaded. Three feed-water heaters each heating a sufficient quantity of water to feed two of the boilers are provided. They are connected with the main exhaust steam pipe, and are fitted with bye-passes and stop-valves, to enable the exhaust steam from the engine to be sent through any of the feed-water heaters or past them. The exhaust pipes are carried from the heaters up the chimney to within a few feet from the top.

At the east end of the buildings are commodious offices and switch and test rooms. The switch room, in which all the electrical connections converge, is fitted with a very complete set of instruments for controlling the current and regulating its distribution between the several circuits. The three alternating current dynamos are connected by separate leads with the private lighting switchboard, so that any one of them can be run on either of the two mains. The arrangements also permit of the machines being run in parallel, and a special synchronising board is provided for this purpose.

The mains from the alternators are first brought to safety fuses in the switchboard arranged so that a fuse can be instantly replaced without stopping the dynamo; and by a system of four break switches any dynamo can be put in communication with any circuit or circuits, or the whole of the dynamos be put in parallel circuit. Besides these mains conveying the entire output of the dynamo, a small wire placed across one coil of the armature is also brought to the switch-room; this is for measuring the voltage, synchronising, and for regulating the pressure. Each coil being similar, the measure of one coil is a direct proportion of the whole, and entirely prevents any inaccuracies that would occur in measuring from a transformer. A simple current meter is also included on the switchboard to indicate to the attendant approximately the current given out by each dynamo. When the maximum safe load of any dynamo is reached, the attendant can either put in another machine parallel or put one of the circuits on some

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lighter loaded dynamo, if working independently. The synchronising is affected through the one-coil circuit; for instance, if one machine shows by the indicator that the load is approaching the normal, and another plant is started, a small switch places the second machine parallel with the first machine, through one lamp only placed on the synchronising board. When the phases of the two dynamos correspond, the lamp is steady and bright, but not until then. The second machine is then instantly put in parallel with the first by the insertion of one main switch, and at once takes half the load. The regulation is also done from the single coil current, a small converter being interposed between it and the regulator to ensure the attendant from any shocks that might accrue from a fault on the circuits or dynamo. A complete set of voltmeters and ammeters is provided, the former being of the well-known Cardew type.

A hand regulator in the form of a variable resistance is placed in the exciter circuits for keeping the voltage constant between the mains. The latter, however, will not as a rule be needed, as three of the Lowrie-Hall Patent Automatic Regulators have been put in connection with the machines. The principal is that of a shunt of varying resistance on the magnet of the exciter.

Automatic regulators of the Brush-Geipel type are put in conjunction with each of the arc lighting machines, and serve to maintain a very constant current in the mains. The principle upon which they work is a shunt on the field magnet circuit of the machines, the excitation of which is modified so as always to maintain the most suitable current in the lamps.

All the instruments for both public and private lighting with the exception of the automatic regulators are fixed to large polished slate bases, supported by a strong wooden framework which forms two sides of the room. Between this frame-work and the brick wall of the building is a passage of about 3ft. wide, with a trench containing the cables running to the street and dynamos; and from these all the necessary connections to the instruments are made and can always be readily inspected.

The mains are laid underground, chiefly below the pavements, and consist of lines of cast iron culverts and boxes into which the cables are drawn. Various sizes of pipes are used from 3in. to 6in. in diameter, the Lowrie-Hall surface boxes, however, are made on the interchangeable system, and are suited to any size pipe, and are placed in the street at a distance of about 70 yards apart. By the aid of these boxes the cables can be drawn out and inspected for repairs if necessary without any further interference to the street from box to box. The pressure on the mains which will convey the electricity to the public street lamps will reach a maximum of 3,000 volts, while the current for lighting up private houses will be transmitted from the dynamo along the cables at 2,000 volts. Before it enters the house, however, it is reduced by means of Lowrie-Hall transformers to 100 volts. Schallenberger meters will be used.

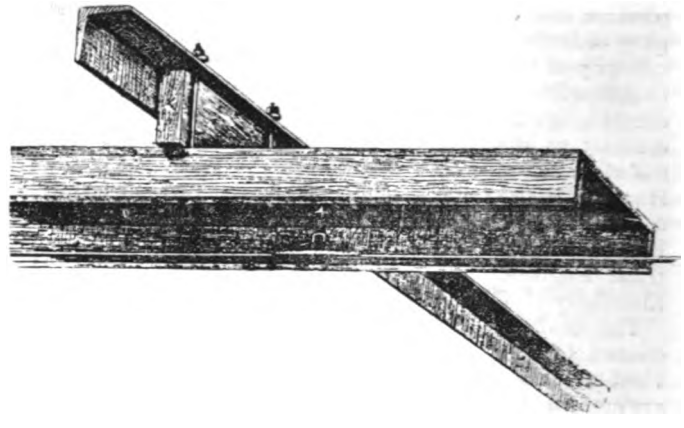
At present only the following streets will be lighted by electricity: Grafton-street, College Green, Dame-street, Parliament-street, Capel-street, Mary-street, Henry-street, Sackville-street, D'Olier-street, College-street, and Westmoreland-street. In these streets are erected 78 lamp-posts reaching to the height of about 23ft. The lamps are of the Brockie-Pell make. The testing apparatus consists of a Wheatstone Bridge in conjunction with a highly sensitive galvanometer of the Sir William Thomson type, with the usual complement of shunts, a reversing key, and a large battery of Leclanche cells giving about 115 volts. Most of the instruments in regular use are attached to a table in the test room of special design, with the connections marked upon the top. The galvanometer stands upon a granite column sunk some 12ft. into the ground to the surface of a hard gravel stratum, the object being to protect the instrument from any vibration which would necessarily interfere with its readings. A complete set of apparatus for restandardising any of the instruments used in the station is also provided, in the shape of a standard current balance, an electrostatic voltmeter, and rheostat resistance, all of the Sir William Thomson pattern. If necessary the house meters can also be readily tested and recalibrated by means of these instruments.

The insulation of the mains is tested by a vacuum tube, one terminal of which is put to earth. If the insulation is good there is a glow in the tube due to the static charges in the conductor, but if there is any defect in the insulation this glow is diminished.

The work has been carried out by Messrs. Hammond and Co., under the supervision of Mr. E. Manville, consulting engineer to the Dublin Corporation, and of Mr. Spencer Harty, City surveyor, assisted by Mr. Mark Ruddle as Clerk of the Works.

ELECTRIC TRACTION IN NEW YORK.

The opposition to the overhead trolley system of electric traction is as stubborn in New York as it is in this country. Nevertheless a line is now being equipped on this system. Its distinguishing feature, to which is probably due the fact that it has been permitted at all, is the attachment of the trolley wire to the structure of an elevated railroad. The way in which this is accomplished will be seen from the accompanying illustration, for which we are indebted to the *Electrical World*. An inverted wooden trough is securely bolted to the iron cross braces of the elevated structure, which are as conveniently placed as if they had been designed for this special purpose. The trolley wire is then carried along the centre of this trough, to which it



Method of attaching Trolley to the Structure of an Elevated Railway.

is attached by means of the insulating fixtures. This not only affords a more substantial suspension than that ordinarily used, but one which protects the wire from rain and sleet and the disastrous swaying of the wind, as well as from falling wires, poles, &c. While possessing these advantages, its simple construction makes it comparatively inexpensive. The expense and trouble of maintaining poles, cross arms, guard wires, &c., is entirely avoided over this portion of the route. The wires, being attached for the major part of the distance to the elevated structure, cannot be said to disfigure the street, as they would not be noticed by the ordinary passer-by, nor could they prove to be an obstruction to the fire department. What is more important, however, they are so completely protected that it is impossible for telephone, electric light, or other wires to fall across them.

HIGH VOLTAGE INCANDESCENT LAMPS.*

BY CAPT. A. DE KHOTINSKY.

In 1881, when I was in Paris, M. H. Fontaine, president of the Gramme Electrical Company, gave me a problem to solve in the construction of high voltage lamps of 250 volts and 200 c.p., limited to absorb not more than 600 watts; his idea was to replace the Jablochkoff candles on the Avenue de l'Opéra. I made several dozen of these lamps, which were submitted to a committee. The result of this test was favourable in all respects, as regards the efficiency and electrical part, but as the committee found it very difficult to watch the lamp during 300 hours (which was stipulated

* Abstract from the *Electrical Engineer* of New York.

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as the necessary life) they determined to test the lamp only six hours, but with 300 volts difference of potential. The highest life under this condition was five hours and 40 minutes, and for this reason the lamps were rejected; and that was the end of my first experiment with high voltage lamps.

During this test the lamps did not blacken on the inside surface of the globe, only a small blue flame was seen on the positive terminal of platinum near the connection of the filament, which flame, a few minutes before it ruptured, jumped many times from one terminal to the other, and at last short-circuited and melted the platinum below the negative terminal of the filament, and in all cases the filaments were left intact. The distance between the terminals was 1¼in. to 1½in., and the length of filament 18in. in each, two filaments being employed in multiple, which crossed each other at an angle of 90 degrees. The filament was punched out of bristol board, and had a section of 400 square mils; the form of the filament was zig-zag, similar to the Weston 100-c.p. filament of 1883.

In 1882 I found it possible to prepare a homogeneous material for manufacturing filaments which, after carbonising, gave a carbon of specific gravity equal to 1·45. In 1883 I formed a company in Rotterdam, Holland, and built a factory to manufacture my high voltage and high efficiency lamp, but, I am sorry to say, the market at that time was not ready to accept my products.

In 1887 I had an opportunity to introduce my high voltage lamps in Block Station, Neue Friedrichstrasse, Berlin; this station had a capacity of 1,200 lamps 160 volts, from 10 c.p. to 150 c.p. each; this station is working at the present moment. In 1888 I made a contract to light a part of the Brussels Exposition with 600 incandescent lamps and 18 arc lamps, all on a 155-volt circuit; and for my high voltage lamps and entire plant I received a gold medal and diploma of honour. In the same year my proposal was accepted for lighting part of the town of Reims, France, on the three-wire system at 320-volts potential, and in September, 1888, this plant of 1,200 lamps was put in operation and is working now with lamps of from 10 to 32 c.p. and 155 volts each. In 1889 Mr. Medhurst installed 2,000 lamps of 160 volts from 16 to 250 c.p. in the cotton mill at St. Petersburgh and many hundreds in South Russia, all working with Parson's turbo-electric generator. In the summer of 1889 there was a demand for my 220-volt lamp in Marseilles, France, and Barcelona, Spain, where they were employed on the three-wire system, 420 volts being the total pressure.

My company, in Europe, gives an absolute guarantee of 1,000 hours for the lamps of 3½ watts up to 220 volts, and the practice of five years proves that the average life is between 1,000 to 1,100 hours. Lamps of high voltage are certainly more expensive to manufacture, and they cannot be sold for the same price as an ordinary 50 or 100 volt lamp, but the difference is not so great, being only about from 15 to 25 per cent. The increase of price in manufacturing consists of platinum hooks by which I attach the filament to the globe, and also from the extra care with which this lamp must be manufactured.

Regarding the brush discharge between the terminals of the filament, I succeeded in reducing it to practically nothing, by special care introduced in the mode of manufacturing. I must say that the brush discharge cannot be annihilated by increasing the distance between the carbon terminals, as suggested, because, according to my practice, the brush discharge depends mostly on the degree of vacuum, the nature of vapour in this vacuum, resistance of contact between filament and leading-in platinum wire, quality of glass from which the bulb is blown (quantity of metal oxides in the glass) and the specific resistance of the filament.

The Deal Time-Ball.—The automatic drop of the Deal time-ball failed on twelve days in 1891 owing to interruption of the telegraph connections; on one day—November 11th—high wind prevented the rising of the ball; and on February 18th the ball was not raised, as some alterations were being made in the cylinder. On October 19th the ball was dropped eight seconds late through the error in the Greenwich signal. On this occasion it was raised again and dropped by hand at fourteen hours. There were repeated failures in the automatic return signal from Deal last November; and it was ultimately found by Captain Wrottesley, R.E., of the Post Office Telegraphs, that these were due to the accumulation of grease which for many years had been applied to the piston on account of the excessive windage in the cylinder, intended to act as an air cushion. The cylinder was cleaned out, the windage corrected by an asbestos pad, remounted, and on February 18th the ball was dropped by hand at fourteen hours. The signal has since been received regularly.

OBITUARY.

FREDERIC NEWTON GISBORNE.

It is with deep regret that we announce the death, on Tuesday last, at Ottawa, of Mr. Frederic Newton Gisborne, Superintendent of the Canadian Government Telegraph Service, and last survivor of the band of pioneers who were associated with early Atlantic cable promotion. Mr. Gisborne died quite suddenly, having only just returned from his annual tour of inspection. He had, we learn, been much affected by the recent death of several of his old colleagues, and more particularly of Mr. Cyrus Field, and, in a recent letter to us, had pathetically referred to the fact of his being the sole survivor.

Mr. Gisborne, who was in his sixty-ninth year, was born at Broughton, in Lancashire. In 1842 he started on a journey round the world, after which (in 1845), accompanied by his younger brother, he sailed for Canada, and purchased a farm near St. Eustache. He subsequently became one of the first operators of the Montreal Telegraph Company, and opened that Company's first station at Quebec, in the old Merchants' Exchange. The British North American Electric Telegraph Association was then formed for the purpose of connecting the maritime provinces with the two Canadas, and Mr. Gisborne was appointed general manager of the Association, and was deputed to visit New Brunswick and Nova Scotia. His mission was successful, and the Government of Nova Scotia erected a line from Halifax to Amherst. From the spring of 1849 to 1851 Mr. Gisborne was superintendent of the Government lines at Halifax.

In 1851-52 the Legislature of the Island of Newfoundland granted him a telegraph construction charter. He visited New York, and obtained all the capital required for his venture, having previously laid before the Hon. Jos. Howe a project for a transatlantic submarine cable connecting Newfoundland and Ireland. On November 27, 1852, Mr. Gisborne laid the first ocean cable on the Canadian side of the Atlantic, connecting Prince Edward Island with New Brunswick. Owing to a disagreement amongst the capitalists, the Company suspended operations, and Mr. Gisborne again visited New York during 1854, where he met Mr. Cyrus Field, the outcome being the formation of a new company entitled "The New York, Newfoundland, and London Telegraph Company," the incorporation being Peter Cooper, Moses Taylor, Marshal O. Roberts, Chandler White, Cyrus W. Field, and Frederic N. Gisborne. Mr. Gisborne eventually completed the work to the entire satisfaction of the Company, after which period he retired for a time from active telegraph work, and devoted several years to mining engineering and railroad construction. In 1862 he represented the interests of Newfoundland, as acting commissioner, at the London Exhibition of that year, and also at the Paris Exhibition in 1867. In 1879 Mr. Gisborne became superintendent of the Dominion Government Telegraph and Signal Service, a position which he occupied at the time of his death.

Mr. Gisborne was a Fellow of the Royal Society of Canada, and a member of the Council of the Canadian Society of Civil Engineers.

Among the various inventions with which Mr. Gisborne's name was associated may be mentioned the following:—Electric, pneumatic, and mechanical ship signals; anti-corrosive and anti-fouling compositions for the bottoms of iron ships; the electric recording target, improvements in gas illumination, &c.; his semaphore was awarded a gold medal at the Fisheries Exhibition. His latest inventions were an anti-induction cable, an iron telegraph pole with iron cross arms—which have been adopted by the Canadian Government for use on their North-West prairies—and an improved telephone.

Our columns have recently contained articles on the various Pacific Cable schemes, for one of which schemes (the Northern route) Mr. Gisborne was responsible, and in all of which he took a very real interest. He was a most genial man, and will be mourned by a very large circle of friends in Canada and the United States.

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THE SCIENCE OF EXHIBITING.

Are we not in some danger of taking the Chicago Exhibition too seriously? Our American friends are past masters in the art of advertising, and in this instance it seems to us they have surpassed themselves. Feeling that the thousands of miles which separate Europe from Chicago were, together with the McKinley tariff, facts neither to be explained away nor exactly calculated to arouse an inconvenient amount of enthusiasm, it was decided to play upon our timidity. Ably seconded, it must be admitted, by the technical press on this side of the Atlantic, the promoters of the Exhibition have been these twelve months and more incessantly dinning into our ears that if we refrain from exhibiting next year at Chicago "the glory of England will be extinguished for ever." On the other hand, the puff direct and the puff indirect have been put in motion, and paragraphs minutely detailing in advance the splendours of the World's Fair Columbian Exposition, 1893, have been reeled off in weekly slips. It is, therefore, not surprising that many traders should have succumbed to the attack, and relinquishing their original attitude of masterly inactivity should have sued for space in a somewhat *sauve qui peut* fashion, with the result that, in the opinion of one of the members of the Royal Commission, the most magnificent display ever despatched from this country to any Exhibition is going to be sent to Chicago. As patriotic Englishmen we are, of course, delighted to hear this, and shall be still more delighted to learn that old markets have been safeguarded, or, better still, that new markets have been gained by England's show at Chicago. It is not within our province, nor would it indeed be possible in the space of a single article, to discuss the question as a whole. Each

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trade must do what seems best in its own eyes. All we would urge is that it is in no case advisable to exhibit in a panic, and that there are other ways of pushing our wares, less showy it is true, but more sure and more scientific.

In this matter as in many others of a similar character, Germany has shown us the way. Much, under the spur of that enterprising country's methods of doing business, has been done and is being done by us to improve our commercial machinery. Organisation never was England's forte; but in this direction, it seems to us, lies our chief hope of retaining our threatened commercial supremacy. On this account we should have preferred to have seen the money, which will shortly be lavished in preparing, despatching, and installing exhibits devoted to purposes such as an agitation for the appointment of men of wide commercial knowledge as consular agents, to the improvement and wider dissemination of consular reports, and to the introduction of some sort of system in many matters of detail where at present the exertions of our "industrials" largely overlap.

But granting that Exhibitions still have their uses, is it not possible to go to work in a more scientific manner? At Frankfort there was a marked tendency to subordinate the natural desire of the individual exhibitor to make the maximum splash to considerations of the general effect. Again, one of the many arguments used to force the laggards into exhibiting at Chicago is that a large number of South Americans will be sure to visit the Exhibition. Let us put the two things together, and consider the outcome. The moral is that we could greatly increase the efficiency of our Exhibition apparatus by bringing it nearer the centre of the area to be supplied, and by arranging its component parts so that potential purchasers should not go away say from the Electrical Department with a hazy notion that while English electrical manufacturers may be all very well for cheap domestic telephonic instruments, they are not to be thought of in connection with high-speed engines and well-made dynamos. In short, Exhibitions should be microcosms of the industries of the country concerned, and not so many testimonies to the success of unabashed advertisers. Exhibitions should be held on the initiative and at the convenience of the exhibitors, and not, as at present, at the beck and call of a rival commercial community. Is it too utopian to look forward to a day when some central commercial body, such, for instance, as the London Chamber of Commerce, will take upon its shoulders the duty of ascertaining from time to time in what countries it would be worth while for such and such English trades to make an exhibit, and then to leave no stone unturned to ensure that before all things there shall be a representative display? Take, for example, these thousands of South Americans, who will, so we are told, travel next year all the way to Chicago, and let us confine our attention solely to electrical engineering. If there is in South America a sufficient demand, actual or potential, for good electrical machinery to justify on that account alone the efforts that have been made to induce the electrical trade to exhibit at Chicago, are we not more likely to secure the trade by a display say at Rio? We should save our South American friends the fatigue of a long journey and we should avoid comparisons, which, as we all know, are odious. Good samples of English engines, boilers, dynamos, motors, mains, lamps, &c., &c., arranged with an eye to the best general effect, would surely be more efficacious somewhere near the equator than on the shores of Lake Michigan.

We do not, therefore, for our own part think that the cold reception of the recent circular addressed to the Electrical Trade is a matter for unqualified regret. It has always seemed to us that, discouraging as were the circumstances under which the manufacturers of the country at large would exhibit, they were doubly so in regard to electrical engineering. Had the Chicago Exhibition executive cared to make the Electrical Department complete they could easily have done so by letting out small portions of the lighting of the buildings and grounds to foreign firms on remunerative terms. In the ill luck which has befallen his proposal, Mr. PREECE will, we trust, console himself with the reflection that he has only met the fate meted out to all men who are so much as five minutes before their time. Exhibiting has not as yet been reduced to a science.

NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 364.*)

15. Slipping Splice (*continued*).—The most usual practice when paying-out cable from the bows after splicing is to wind back the slack of the splice on the drum, and as soon as the cable is taut and the strain taken by the drum the bow stoppers are removed and paying-out begins. The position of the completed splice is shown in the deck plan in Fig. 53. The end of the submerged cable on which the ship

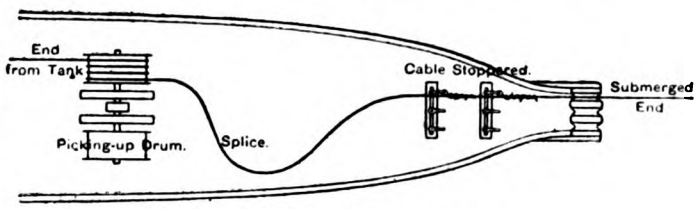

FIG. 53.—Preparing to pay-out.

has been picking up is stoppered at the bows with sufficient slack inboard to make the splice; and the other end from tank is taken round picking-up drum and brought forward for splicing. When the splice is completed, the drum is driven backwards as in picking-up, and the slack bight of cable containing splice is wound in on the drum. The appearance of this on deck is shown in Fig. 54, the slack being taken up, but

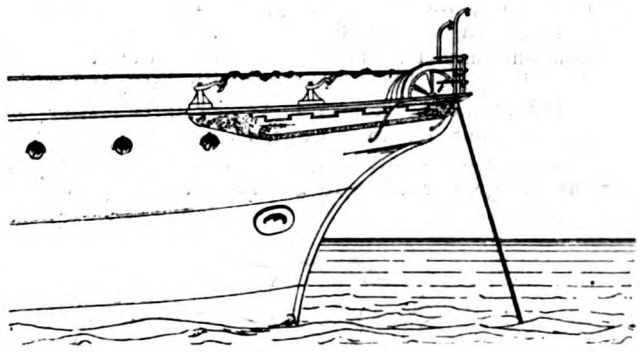

FIG. 54.—Cable stoppered at Bows.

not quite far enough to relieve strain from bow stoppers. A foot or two more heaved in transfers the entire strain from the stoppers to the drum, and this being done the stoppers are removed. The cable is then in a fair way for paying-out.

16. Cable Stoppers.—On cable ships, for use in stoppering cable, two iron frames similar in shape to that illustrated in Fig. 57, are usually fixed about 4ft. apart, close to the bow baulks. The position of these frames on the deck is indicated in plan in Fig. 53. Each frame supports two or three strong wrought-iron hooks, bent downwards as shown in Figs. 56 and 57, and to these hooks are attached the eyes of the rope stoppers used in fixing the cable.

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The rope stopper is made out of a piece of three or four inch Manilla about twelve feet long. First an eye or loop is made at the centre of the piece, and then the two ends are unlaid and plaited half round sennit, as in Fig. 55. The plaited ends near the eye are somewhat larger in diameter than the original rope, but the plait is gradually tapered down to very small ends, which are tied with a little fine yarn to keep them from opening out. The plaited rope has a much rougher and uneven exterior than the original stranded rope, thus offering a greater surface for gripping the cable; and besides this it is extremely supple, and easily bent round the cable.

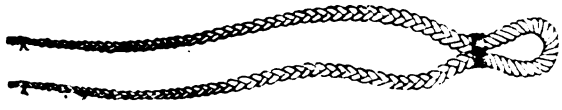

Fig. 55.—Manilla Rope Stopper.

The manner of fixing the rope stopper on to cable is shown in Fig. 56. The cable passes from the bow sheaves immediately over one or other of the hooks. A rope stopper is taken, the eye passed over a hook, and the tails of the stopper taken one on each side of the cable, and held up above the same, one in each hand. They are then crossed and folded downwards over the cable, one end (say, A) overlapping the other (B). They are then crossed and brought up again, this time B overlapping A on the under side of cable. Again crossed and folded down, A overlapping B as at first, and again crossed and folded up, B overlapping A, and so on, up to the end of stopper. This alternate overlapping is shown in the sketch (Fig. 56), exactly as it appears when complete. The tail ends of the stopper are finally bound round tightly to the cable with yarn, and seizings are also put round the stopper in two or three places. Two such stoppers put on to a cable, as indicated in Fig. 54, one behind the other, are ample to hold it in the deepest water, as the greater the pull the more the stopper binds.

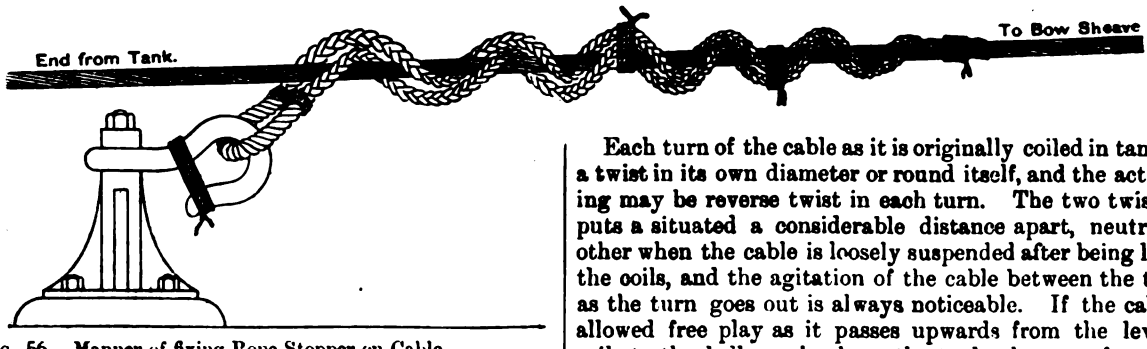

Fig. 56.—Manner of fixing Rope Stopper on Cable.

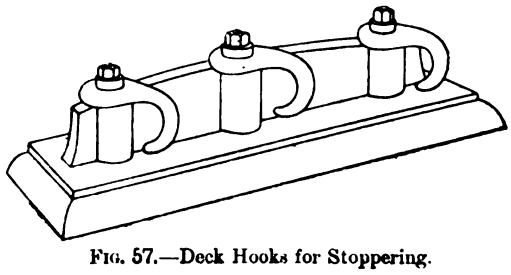

Fig. 57.—Deck Hooks for Stoppering.

When it is required to ease cable out from the stoppers the end seizing is taken off and the two tails held in the hands, when, by easing them bit by bit the cable is allowed to slip through.

17. Paying out.—The ship now proceeds to pay out at a speed of four or five knots, the course being in a direct line for the position of the buoy on the other end. In the testing room watch is kept continuously on a spot of light from the galvanometer, which remains stationary so long as the cable leaves the ship in a perfect electrical condition. Should the insulation fail from any cause the galvanometer would instantly show it, and the ship would be stopped. At intervals the shore is communicated with, and the instructions sent by ship are usually a repetition of "Free one hour, then look out" as paying-out proceeds, The battery on board being connected to cable through galvanometer, only the usual minute current through the insulation can pass while the end on shore is free, and this deflection on the instrument remains constant, unless a fault is payed out.

In the tank careful precautions are taken to prevent the cable "taking charge." Men are stationed below, inside the tank, who see that not more than one turn at a time is lifted, and that the bights between adjacent flakes are properly guided out, so as to avoid kinks forming. In large tanks, by the use of what is known as the crinoline, the cable is guided towards the centre from the moment it is lifted in paying out, and by this means the formation of a kink or a foul flake is of very rare occurrence. The crinoline consists of a set of three or four iron rings of different sizes, the largest being below. These fit over the cone in the tank, as shown in Fig. 58, the cable passing upwards between the rings and the cone. Mr. R. S. Newall, of Sunderland, first introduced the use of the cone and rings in fitting up the earliest cable ships. Before the cone was introduced, it was not uncommon for one of the inner turns to slip down in the centre, and when lifted either jam or form a kink. The cone shown in the sketch is telescopic, so that its height can be regulated to the amount of cable coiled, and thus economise space above cable.

Each turn of the cable as it is originally coiled in tank receives a twist in its own diameter or round itself, and the act of uncoiling may be reverse twist in each turn. The two twists, which puts a situated a considerable distance apart, neutralise each other when the cable is loosely suspended after being lifted from the coils, and the agitation of the cable between the two twists as the turn goes out is always noticeable. If the cable is not allowed free play as it passes upwards from the level of the coils to the bellmouth above the tank, the turn formed by the twists at coiling and uncoiling may not go out, but be carried on further as the cable passes the pulleys on deck. By means of the crinoline the cable is guided almost vertically from the level of the coils to the bellmouth above the tank. The rings, which are of ½in. or ¾in. gas pipe, are fastened rigidly together, as shown in the illustration, and are also attached to guides at side of tank, so that they maintain a central position when being raised or lowered. Blocks and falls are fixed, as shown, by which the men can raise or lower the crinoline according to the height of cable in tank, the position for the lowest ring being about 1ft. or 2ft. above level of cable.

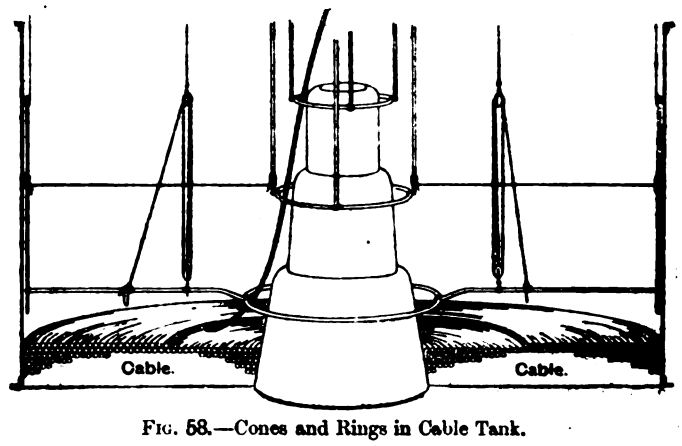

Fig. 58.—Cones and Rings in Cable Tank.

To save time, it is customary to make the necessary splices between coils while paying out is going on. When there is a

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coil of the required type, uppermost in one of the tanks, and sufficiently long to cover the distance to the buoy, no splices are of course necessary; and this arrangement of cable is

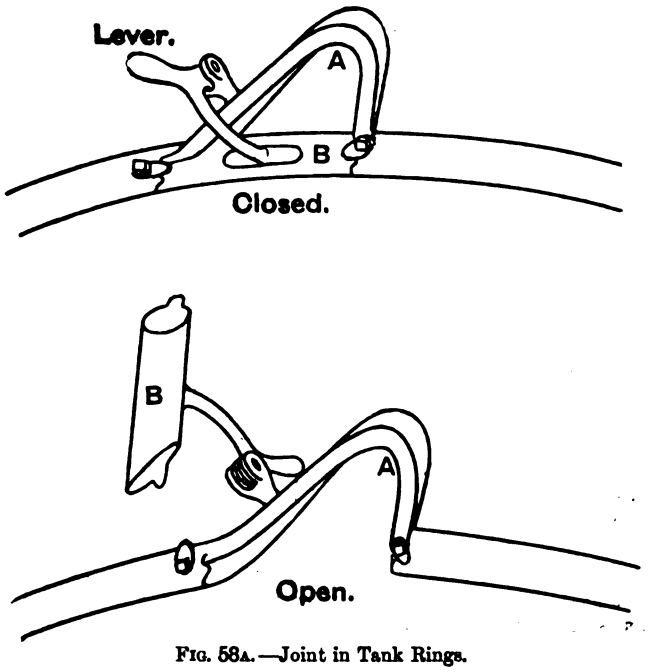

FIG. 58A.—Joint in Tank Rings.

generally made beforehand while ship is steaming out to her first position, the type of cable at the position being well-known. It is, however, sometimes more convenient to relay the cable which has just been picked up, provided it is in good external condition and tests well. If the repair has been simply that of a total break of the cable, it is usual to splice on at once the lengths picked up and relay them, adding on the extra length necessary; but if the repair has been that of a fault, the last length picked up which contains the fault must be coiled in a different tank. And whenever the same cable is relaid after picking up, it generally lies in short coils which, to save time, are spliced together as the ship proceeds, so that when the end of a coil is reached it is only necessary to slow down a few minutes, while bight of splice is lifted instead of waiting two hours. Should it be required to change tanks, that is, to continue the paying out from another tank, the splice is made in the same manner between the underneath end of first coil and the top end of coil in the other tank, but a special arrangement is necessary to allow the bight of splice to lift free of the rings in the first tank. For this purpose each ring is provided with a joint or opening of a similar description to that in illustration, Fig. 58A., the construction of the joint here shown being that employed on the ships of the Silvertown Company, by whose courtesy the sketch is lent. A piece of curved iron (A) is fixed across the gap in the ring, so as to form a loop or pocket when the ring is complete. It will further be seen by the illustration that the short length B of the ring which can be withdrawn to form a gap, or replaced to complete the ring, is moved by a lever pivoted on a bracket fixed to the iron loop A. While cable is paying out the gap in each ring is closed, the short piece B being fastened in by catches, and the underneath end of the coil is passed up through the pocket in each ring formed by the loop A. The end brought out at the top is then spliced on to end in next tank. When nearly up to splice ship is slowed down, and the bight allowed to pass up by opening the gaps in the rings; the movement of the cable is then unobstructed to the next tank, and paying out proceeds at the usual rate. Generally the crinoline is not found necessary in tanks less than a certain size, say 25ft. in diameter. On board the large cable-laying vessels of the Telegraph Construction Company a telescopic guide answering the above purpose has been designed by Captain R. C. Halpin. This is fixed over each tank, and can be raised or lowered by a simple gear.

The brake power applied to the shaft of the paying-out drum is the principal means of preventing the cable running out too fast or taking charge. These brakes are now made with wheels of 6ft. or 8ft. diameter, upon the face of which all round the circumference bear a set of wood blocks fastened to an iron brake band, as in Fig. 59. This band can be tightened by a right and left handed screw, which is operated by a hand wheel. In the cable ship "John Pender" (Eastern Telegraph Company) this hand wheel is on the bridge level, as shown in sketch,

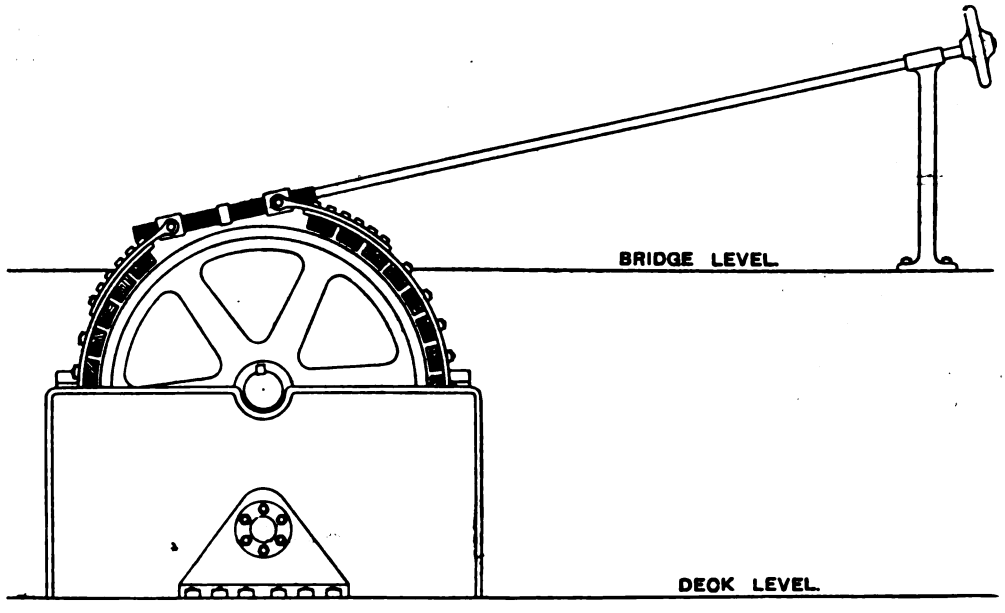

FIG. 59.—Brake on Paying-out Drum.

where the brakesman stands in full view of the cable as it passes out. The brake wheel is kept cool by revolving in a tank of water.

(*To be continued.*)

THE "BRAIN" COVERED CONDUIT SYSTEM OF ELECTRIC TRACTION.

The principal methods of conveying electric power to tramcars or trains are, through the surface rails, through overhead conductors, by means of storage cells in the cars, and through conductors placed in conduits between the rails below the ground level. The system under consideration—the invention of Mr. C. T. Brain, of Liverpool—belongs to the last class but differs in some important details from the usual form in which underground conduits are designed. It is customary to

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allow of the electrical communication between the car and the conductor by means of an open slot in the top of the conduit, through which the collector, travelling with the car, passes. access to the conductors for repairs; and the ease with which mischievous persons can do damage by poking metal rods through the slot, short-circuiting the current. It may also be pointed out

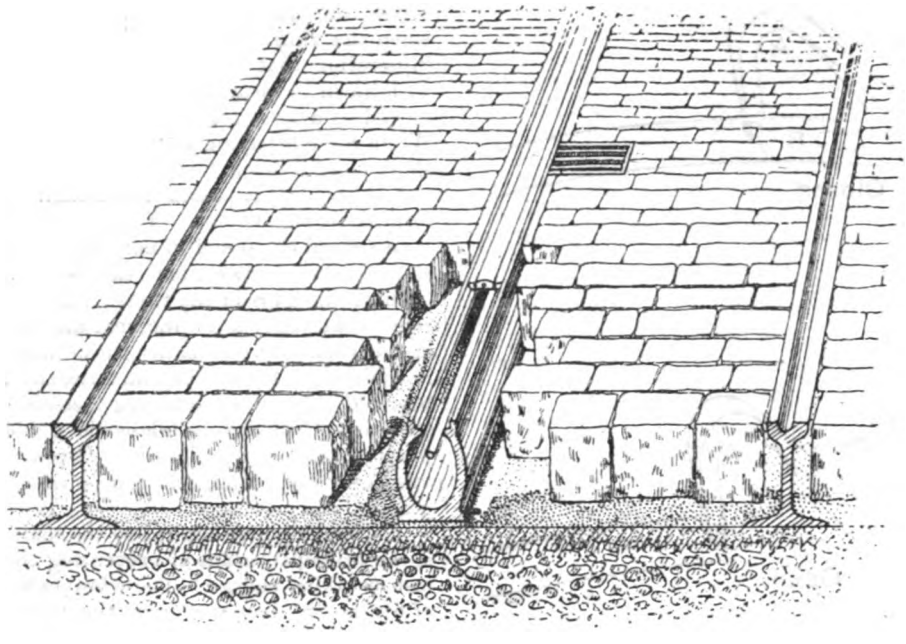

FIG. 1.—Iron Rails and Conduit, showing Cover-Rail, Surface Box, and Conductor.

There are many objections to, and difficulties in working, the open-slotted conduit; and, however superior this form may be

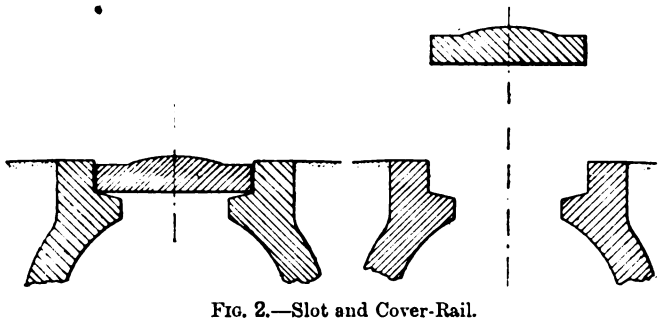

FIG. 2.—Slot and Cover-Rail.

to either of the other forms which have been mentioned, it is certain that success cannot be assured till these obstacles have been surmounted. The difficulties are principally in the admission of dust, mud and rain-water through the slot, choking the conduit, breaking down the insulation, and impeding the passage of the collector over the conductor; the difficulty of that a wide slot is a source of danger to traffic; while a narrow one involves weakness in the collector at the point where it passes through the slot. The Board of Trade limits open slots to a maximum width of half an inch. In the "Brain" covered conduit these difficulties have certainly been overcome, though at some trifling increase of tractive effort.

A general idea of the arrangement in this system is given by the adjoining sketch (Fig. 1), which shows the position of the cast-iron conduit relatively to the ordinary rails of the tramway. Inside the conduit is a solid circular conductor of phosphor bronze, supported at intervals of about 14ft. on insulators, which are accessible through surface boxes. Connection between the car and this conductor is made through a slot 1½in. wide, at the top of the conduit, the edges of the slot being flanged so as to form a seat for the slot-cover or cover-rail (Fig. 2). This cover consists of a flat strip of mild steel of rectangular section, about 1¾in. wide and half an inch thick. When not in use the slot is covered by this cover-rail,

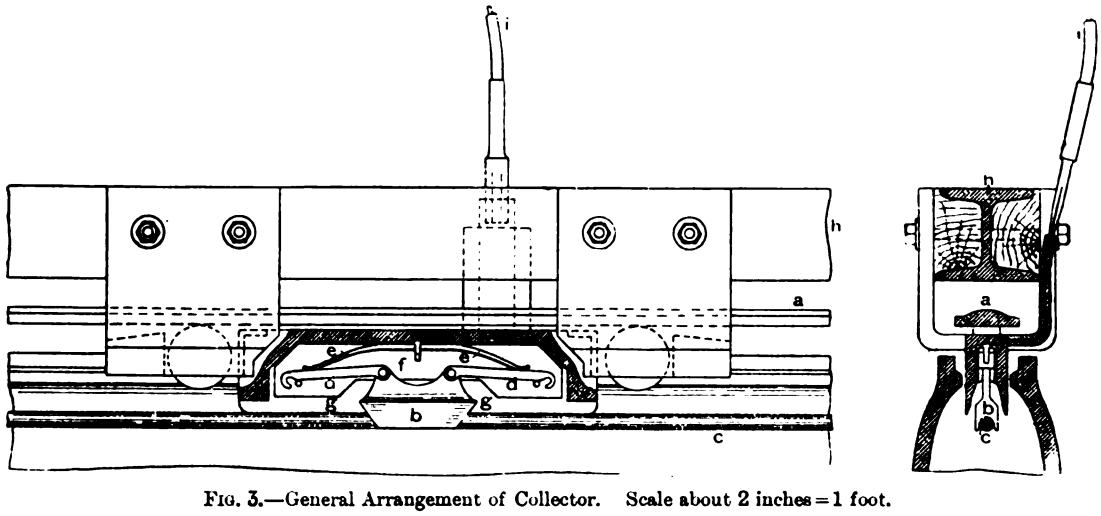

FIG. 3.—General Arrangement of Collector. Scale about 2 inches = 1 foot.

the latter fitting into its seat flush with the road setts. When a car is passing, the cover is automatically lifted about 2in. by the collector, which is fixed to the motor truck of the car. The arrangement for lifting the cover and taking

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off the current from the conductor is shown in the illustration, Fig. 3. To the girder, *h*, which forms part of the motor truck, are attached four small rollers which press against the under surface of the cover-rail, and two larger rollers (not shown) which press against its upper surface, fore and aft of the other set. These are so arranged that the cover is lifted from the slot by the former set, and replaced by the latter set. The natural elasticity of the rail is found to be sufficient to replace it, but the two top wheels are used as a safeguard. Under the cover-rail, and between the lower set of rollers, is the collector shoe, *b*, which glides over the top surface of the conductor, *c*, and partially embraces its sides, making good contact by means of the springs, *e*, in the lock-frame, *f*. The width of the slot permits of $\frac{3}{8}$in. thickness of insulation on each side of the collector, besides a good thickness of sheathing; conditions which render it mechanically and electrically reliable, and superior to the open slot. Insulation boxes, containing bracket insulators for the conductor, are placed at intervals along one side of the track, and can readily be opened for cleaning and repairs. Each of these boxes is about the size of a granite road sett. At longer intervals there are sumpholes from which the accumulation of mud and dust can be withdrawn after the conduit has been flushed with water.

The cost of keeping up the insulation is very trifling, as the conduit is almost always sealed by the cover-rail; and the little accumulation which takes place can readily be removed by flushing. Every part of the conduit is placed centrally, so as to accommodate cars passing in either direction, without the necessity for any adjustment of the collector. At crossings and turn-outs the conductor is flattened into a broad rectangular strip, on the top of which the collecting shoe glides without embracing the sides of the conductor. By this means the car is enabled to pass along either track without any hitch or jolt at the junction of the conductors. The only mechanism of any sort at these points is most simple, being on the road surface, visible and easily handled. The centre cover-rail is pivoted, like the movable tongue at the points of ordinary rails; being, of course, in the reverse direction, as the pivot is at the centre point of the fork. This short movable strip of cover-rail reaches from the centre point of intersection to the point where the inner edges of the two centre cover-rails meet. These rails being cut off at this point have their ends recessed, or grooved out, the end of the movable tongue being made to swing into these grooves. A short U-piece goes round the conductor and rises up on each side near the end of the movable tongue; a bar connected with this is fitted to the ordinary movable rail points, or any suitable lever fitted in the groove of the rail, so that the cover-rail tongue is always moved to that side which the car wheels are made to take. In the ordinary turn-outs where the rail points are made automatic, the car flanges opening them as they leave the turn-out, the cover-rail tongue is made automatic also. As this tongue swings over to the side which the car takes, its end fits into the end of the cover-rail on that side. When the carrier wheel, or front top roller, is passing the whole works as one continuous rail, just as on a piece of straight line.

One of the most striking features in this system is the easy accessibility of every part of the conduit. The conduit can be opened as fast as a car can be run over the track; for, by a simple adjustment of the top rollers, the cover-rail can be deposited on the road setts, to the right or left of the slot, as the car passes along; thus exposing the entire length and width of the conduit. By running the same car backward over the track, the cover-rail will be picked up and replaced in the slot. The insulator brackets, being all on one side of the conduit, allow of the passage of scrapers or brushes along the conduit when it has been thus opened.

On a length of experimental line which has been laid at the works of the Telegraph Manufacturing Company, at Helsby, this system has been subjected to a series of tests extending over a period of two years. Difficult crossings, sharp turn-outs, and curves have been laid, and the behaviour of the conduit examined in all weathers. It has been found that the power required to lift and replace the cover-rail is so trifling that its cost must be more than met by the saving in other expenses, for even in a severe frost the addition to the tractive force is less than five pounds. In ordinary weather the accumulation of material in the conduit is so small that working order can easily be maintained by nothing more than a water flush once in every two or three weeks; and opening the conduit in the manner described seems to be a rare occurrence. It seems probable that the system designed by Mr. Brain—unencumbered as it is by the heavy loads of the battery system, by the ugly unsightliness of the overhead wire, by the dangers of the conductor rail, or by the mechanical defects of the open slotted conduit—will be an important step towards the perfection of electric traction.

COMPARATIVE MERITS OF THE TWO-PHASE AND THREE-PHASE SYSTEMS.

The latest contribution to the discussion on the relative merits of three and two phases, which has been going on for some little time in the columns of our New York contemporary, the *Electrical World*, and which we summarised in our issue of August 5th, is by Mr. C. E. L. Brown, who writes as follows:—

My extensive experience with multiple-phase currents has shown me that motors for the two-phase and those for the three-phase system for the same output are very much the same machines with regard to their respective efficiency, starting torque, weight, and apparent watt consumption. This holds good for synchronous as well as non-synchronous motors, and shows plainly that Mr. Kelly's, as well as Mr. Steinmetz's theoretical deductions are founded on the true basis.

I make use of this occasion to state that Prof. Ferraris, Gisbert Kapp, and Mr. Tesla also expressed themselves to that effect in an interview I had with them some time ago.

Again, another proof of the correctness of Mr. Kelly's and Mr. Steinmetz's deductions can, I believe, be taken from the fact that Mr. Tesla, who, as is well known, had already in his first patents brought the three-phase current to notice, nevertheless devotes his special attention to the two-phase current system, and I believe rightly, for as soon as there is a question of distributing electric light and power efficiently, there is no doubt that the two-phase has many advantages over the three-phase current.

This latter system allows a very efficient distribution of power only, but as soon as any light has to be supplied in connection with power, the mutual dependence of the currents presents great difficulties in the way of regulation. The connection, too, of the lamps with the mains becomes naturally rather complicated. All electrical engineers know that already the connection to an ordinary three-wire system is comparatively complicated, but these difficulties increase very considerably with the three-phase system, as with this three groups of lamps will always have to be connected with the three wires.

In using the two-phase current all these difficulties are done away with, as the connections of the lamps can be made similar to those on an ordinary alternate current circuit.

The regulation presents no difficulty whatever, and motors can be driven by this system just as well as by using the three-phase current.

It is, therefore, my belief that in the future the two-phase current will take the lead where combined light and power distribution is required, while the three-phase current may be used for simple power transmission and distribution.

The points I have brought up in the above few lines are not to be taken as merely theoretical, but are proved by experience and many actual tests in practice. I have at the present moment installations in hand for many 100 H.P. for the two-phase system, and I am altering a large installation from the three-phase to the two-phase system, as the same is now required for light in addition to the distribution of power, which was originally intended exclusively.

In reply to the remarks of Mr. Steinmetz, that at the Frankfort installation the small number of periods was taken merely at random, I beg to say that this is not the case, but the number of periods was fixed according to very careful and elaborate tests. With this, however, I do not intend to say that motors with larger numbers of periods could not be produced in practice.

BOOKS, &c., RECEIVED.

"Hydro-Electric Methods in Medicine." By W. S. Hedley, M.D. (London: H. K. Lewis.)

"Calendar of University College, Liverpool." Engineering Department. (Liverpool: F. and E. Gibbons.)

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TRANSFORMERS.*

BY JOHN PERRY, D.SC., F.R.S.

I. In a transformer with many circuits, of resistances in ohms and numbers of turns, R_1, N_1, R_2, N_2, &c.; let the current at any instant be C_1, C_2, &c., amperes, and let the independent electromotive forces e_1, e_2, &c., volts be maintained in them; let I be the total magnetic induction which threads through all the circuits (10^8 C.-G.-S. units being taken as the unit of induction). The equations to the circuits are—

$$e_1 = R_1 C_1 + N_1 \theta I, \quad e_2 = R_2 C_2 + N_2 \theta I, \text{ &c.},$$

using θ for d/dt.

Multiplying each equation by its N and dividing by its R and adding, we find, using A for the ampere turns, $N_1 C_1 + N_2 C_2 + \&c.$ and q for $\frac{N_1^2}{R_1} + \frac{N_2^2}{R_2} + \&c$

$$A + q\theta I = \Sigma(N_i/R_i) e_i. \quad . \quad . \quad . \quad . \quad . \quad (1).$$

If the law connecting A and I is known, it is possible to calculate I from (1), and then substituting for I in each of the circuit equations, each of the currents is known.

Instead of e_i being the electromotive force in a complete circuit it may be the potential difference maintained at the terminals of a circuit, and the letter V_i will then be used, the resistance between the terminals being R_i. If e_i or V_i has any value the circuit is called a primary circuit. When no independent electromotive force is maintained in a circuit it is called a secondary circuit.

II. Substitution of one coil for two or more:—It is evident from the way in which (1) is derived, that instead of a primary coil (V_1, N_1, R_1) and a secondary (N_2, R_2), if we substitute a primary (V_1, n_1, r_1), and if $n_1/r_1 = N_1/R_1$, and also if $n_1^2/r_1 = N_1^2/R_1 + N_2^2/R_2$, then the currents in all the other coils will be the same as before. We can therefore replace a primary and any group of secondaries by one primary coil.

It is also evident that if any group of secondaries (N_p R_p), (N_t R_t), &c., replaced by one be secondary (n_2, r_2) such that $n_2^2/r_2 = N_p^2/R_p + N_t^2/R_t + \&c.$, all the other currents will remain as before. It is, in fact, evident that if for groups of primaries and secondaries we substitute one primary coil of suitable potential difference at its terminals and resistance and number of turns, all the currents in the remaining coils will remain the same.

If two secondaries of numbers of turns N_p and N_t and internal resistances r_p and r_t have the same terminals, and together supply a current to an outside circuit, for them we may substitute one secondary of n turns and internal resistance r ohms with a permanent short circuit of resistance ρ between its terminals, if

$$n = (N_p^2/r_t + N_t^2/r_p)/(N_p r_t + N_t r_p),$$

$$r = r_p r_t (N_p^2 r_t + N_t^2 r_p)/N_p r_t + N_t r_p)^2,$$

and

$$\rho = (N_p^2 r_t + N_t^2 r_p)/(N_p - N_t)^2.$$

Hence no good results can be expected from compound winding. If, instead of requiring a perfect similarity in all respects, we desire a substitution which is almost absolutely perfect in practical cases, we can obtain it by the use of a single coil with no short circuit outside, and therefore without the excessive waste of power which occurs when two coils of different numbers of turns are compounded. This last result is obtained by regarding A as a negligible term in (1).

Two coils in parallel to one another, used as a primary or secondary, will evidently waste energy in idle currents inside the transformer unless they are exactly equal in their numbers of turns.

III. If condensers are connected with any of the circuits the most general case is this:—Take the internal resistance of the sth coil to be r_s; let it have a condenser outside a capacity K_s in series with a resistance ρ_s'' and let there be a resistance ρ_s' in parallel with ρ_s'' and the condenser. Then, in the general expression, instead of R_s we must use

$$r_s + (\rho_s' \rho_s'' K_s \theta + \rho_s')/\{(\rho_s' + \rho_s'') K_s \theta + 1\}.$$

Having found C_s, we must remember that the part passing through ρ_s' is $(\rho_s'' K_s \theta + 1) C_s / \{(\rho_s' + \rho_s'') K \theta + 1\}$. Everywhere when any resistance r is spoken of, if there be also a coefficient of self-induction l (or in case it is an internal resistance r_s that is spoken of, should there be magnetic leakage), we must use instead of r the expression $r + l\theta$. Our formulæ, in case there is magnetic leakage, in case there is self-induction, or in case there are condensers, really require that a complicated operation

$$\frac{a + b\theta + c\theta^2 + d\theta^3 + e\theta^4 + f\theta^5 + \&c.}{a' + b'\theta + c'\theta^2 + d'\theta^3 + e'\theta^4 + f'\theta^5 + \&c.}$$

should be performed upon a function of the time. Now the functions with which engineers deal are periodic functions, and the evanescent parts of the answers may be left out of consideration. As any periodic function of the time is the sum of simple harmonic functions, we have only to perform the above operations upon functions like $\sin(kt+m)$. But it is obvious that the complicated operation when performed on $\sin(kt+m)$ reduces to

$$\frac{(a - ck^2 + ek^4 - \&c.) + (b - dk^2 + fk^4 - \&c.)\theta}{(a' - c'k^2 + e'k^4 - \&c.) + (b' - d'k^2 + f'k^4 - \&c.)\theta},$$

an operation which is very easy to perform.

Writing it in the form $(p + q\theta)/(a + \beta\theta)$, the result of operating upon $\sin(kt+m)$ is to convert it into

$$\sqrt{\left(\frac{p^2 + q^2k^2}{a^2 + \beta^2k^2}\right)} \sin\left(kt + m + \tan^{-1}\frac{qk}{p} - \tan^{-1}\frac{\beta k}{a}\right).$$

Hence the most complicated cases are readily worked out when numerical examples are taken. Engineers are in the habit of speaking of the epoch m as a lead when it is positive, and as a lag when it is negative. The reciprocal of the periodic time is called the *frequency*, and k is $2\pi \times$ frequency.

IV. Law connecting A and I:—

1. If μ, the magnetic permeability of the iron, is constant, let σ stand for $4\pi a \mu 10^{-9}/\lambda$ where a is the area of cross section of the iron in square centimetres, and λ is the average length of the induction solenoids in centimetres. The curve which on squared paper illustrates the magnetic law is a straight line, and $I = \sigma A$.

2. If the curve is not a straight line, that is, if there is some indication of saturation, and there generally is some saturation where β the induction per square centimetre exceeds 2×10^{-5} (or 2000 C.-G.-S. units), it will be found that a good approximation to actual facts is obtained by assuming that when $I = I_0 \sin x$, $A = A_0 (\sin x - b \sin 3x + m \sin 5x + \&c.)$ where $I_0/A_0 = \sigma$, a constant, and n is any quantity which increases continuously. Thus it will be found that taking only one harmonic, $b = 0{\cdot}2$ gives a close approximation to what may be the actual case in transformer problems. Taking two harmonics, $b = 0{\cdot}2$ and $m = 0{\cdot}05$, gives a better result. There is no hysteresis in such cases.

3. If the curve is a simple hysteresis loop such as may be obtained in slowly-performed cyclic magnetisation, on the assumption that $I = I_0 \sin x$, one of my students, Mr. Fowler, has found A in terms of $\sin(x + e_1)$, $\sin(2x + e_2)$, &c., a rather complicated expression which I need not give. But another student, Mr. Field, finds that the approximation $A = A_0 \{\sin(x + f) - b \sin 3x + m \sin 5x\}$ is sufficiently accurate for many purposes of calculation if $b = 0{\cdot}2$ and $m = 0{\cdot}05$. However complicated the law may be, it can be expressed in the shape:—If $I = \Sigma I_i \sin(i x + e_i)$ then to the ith term in I there correspond the terms in A, $(I_i/\sigma_i)\{\sin(i x + e_i + f_i) - b_i \sin 3 i x + m_i \sin 5 i x + \&c.\}$.

Our first assumption of constant permeability applied to a transformer with one primary and many secondaries causes equation (1) to become $A = (1 + q\sigma\theta)^{-1} N_1 V/R_1$, and hence

$$-C_s = (N_s N_1/R_s R_1)\{\sigma\theta V/(1 + q\sigma\theta)\}.$$

I will, for the sake of illustration, consider a 1,500-watt transformer, which is a specimen of many in use. One primary coil $R_1 = 27$ ohms, $N_1 = 460$ turns. Internal resistance of the one secondary coil $= 0{\cdot}067$ ohm, $N_2 = 24$ turns. Effective primary potential difference $= 2{,}000$ volts or $V = 2{,}828 \sin kt$. Frequency about 95 per second, or $k = 600$, $a = 360$ square centimetres, $\lambda = 31$ centimetres. It will be found that the highest value of β, the induction per square centimetre, is $2{\cdot}755 \times 10^{-5}$ (or 2,755 C.-G.-S. units). If there are neither condensers, nor self-inductions, nor magnetic leakage, and if $\mu = 2{,}000$ (it will not much affect our results to take $\mu = 1{,}500$ or 3,000), then $\sigma = 3 \times 10^{-4}$; if there is no load on the transformer $q = 7{,}837$, and if there is full load, when $R_2 = 6{\cdot}8$ ohms, $q = 7{,}922$. It is evident from these numbers that in practical cases $1 + q\sigma\theta$ is nearly the same as $q\sigma\theta$. Neglecting the 1 means neglecting an alteration of 1/500,000th of the amplitude and lag of 1/200th of a degree. We see that in this case neglecting the term A in equation (1) is quite allowable, and if such a transformer had one primary and many secondary circuits, we might at once write

$$I = N_1 V_1/R_1 q\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$-C_s = N_s N_1 V_1/R_s R_1 q \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Of course, with any law of magnetisation these are the answers if A may be neglected in equation (1).

Taking the third assumption, the simplest hysteresis cycle, which when $f = 0$ is also the second assumption. If $I = A_0 \sigma \sin kt$, (1) gives for V_1 the value

$$V_1 = \frac{A_0 R_1}{N_1}\{\cos f \sin kt + (\sin f + q\sigma k)\cos kt - b \sin 3kt + m \sin 5kt\}.$$

If $k = 600$, or a frequency of 95 per second, the lowest value of $qk\sigma$ for the above-mentioned transformer is 1,411, so that taking f of any value whatever, and b and m even much larger than the values given above, it is obvious that for all practical purposes, certainly

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in the case where it is the effective value of V_1, which is important, the above expression for V_1 is the same as if f, b, and m were zero. No doubt V_1 does possess small traces of the higher harmonics; but taking the above values for b and m, and taking $f=20°$, I find that the error in neglecting f, b, and m, in calculating the effective voltage, is utterly insignificant. I have applied to this problem the most complex law of magnetisation which I could formulate, which was at all likely to be true, and in all cases I have arrived at the same result:—Given the voltage V_1 at the terminals of a primary coil of a transformer with many secondary coils, the induction and the secondary currents may be calculated from 2 and 3, which were worked out on the assumption of constant permeability, and in all cases the error in the effective values is exceedingly small.

V. *Magnetic Leakage.*—If all the induction due to the current in any coil does not thread through all the other coils, the effect of leakage is obtained by assuming that each N is really less than the number of turns, and that there is some self-induction in each circuit in addition to $N^2\sigma$. If the additional inductances are l_1, l_2, &c., then, in our expression R_1, R_2, &c., will be replaced by $R_1+l_1\theta$, $R_2+l_2\theta$, &c. Thus, in the above-mentioned 1,500-watt transformer, let I_0 represent the induction when there is no load on the transformer. Assume that 1 per cent. of the induction due to the primary current escapes the secondary, and that 1 per cent. of the induction due to the secondary current escapes the primary, or that $l_1=10^{-2}N_1^2\sigma=0{\cdot}6348$, $l_2=10^{-2}N_2^2\sigma=1{\cdot}738\times10^{-3}$. Let I be the induction at full load, or when $R_2=6{\cdot}8$ ohms. When there is no magnetic leakage $I=0{\cdot}99\,I_0$; when there is 1 per cent. magnetic leakage $I/I_0=(1+2{\cdot}54\times10^{-4}\theta)/(1{\cdot}0108+5{\cdot}08\times10^{-4}\theta)$. Assuming I_0 to be $\sin kt$, I give the values of I for various values of k.

k.	I.
100	$0{\cdot}988\sin(kt-1°{\cdot}4)$
300	$0{\cdot}981\sin(kt-4°{\cdot}2)$
600	$0{\cdot}958\sin(kt-8°{\cdot}1)$
1,000	$0{\cdot}912\sin(kt-12°{\cdot}4)$
2,000	$0{\cdot}782\sin(kt-18°{\cdot}2)$
4,000	$0{\cdot}628\sin(kt-18°{\cdot}1)$

VI. *Eddy Currents.*—There is eddy current loss of power in all the conducting masses near a transformer. If we assume that the induction per square centimetre β is the same everywhere, and if it follows the law β (in C.-G.-S. units) $=\Sigma\, a_i \sin(ikt+\epsilon_i)$, the average power in watts wasted in eddy currents in the iron per cubic centimetre is $6{\cdot}25\times10^{-13}\,r^2k^2\,\Sigma\, i^2a_i^2$, if the specific resistance of the iron is taken to be 10^4. The iron is supposed to be of wire of radius r centimetres.

The average power wasted in the iron is less at high temperatures, being inversely proportional to the specific resistance of the iron. It is evidently proportional to the square of the effective primary voltage in the unloaded transformer, but, of course, magnetic leakage causes a diminution when the transformer is loaded. In fact, the eddy current loss is always proportional to the square of the effective electromotive force in the secondary circuit. In applying the rule, it is to be remembered that the induction is not uniform in the section of a wire, nor is the average induction in each wire the same for all the wires, and, therefore, the real loss of power in the iron by eddy currents is always greater than the result of applying the above formula.* If we assume that one secondary circuit closed upon itself represents all the eddy current circuits, assuming the truth of the above formula is the same as assuming no magnetic leakage between the primary and this eddy current circuit. Assuming magnetic leakage gives the more correct result, which is practically that the magnetisation is greater in wires near the surface of the mass of iron than it is internally, and also that the induction is greater near the skin of each wire.

Such experiments as have hitherto been made do not enable us to say to what extent the eddy current loss is increased by this cause. In the above-mentioned 1,500-watt transformer there is 10 per cent. less eddy current waste at full load than at no load, because of the change in q^2 and also because of magnetic leakage, and there may be 50 per cent. less eddy current waste due to the higher temperature of the iron.

VII. *Unloaded Transformer.*—When there is a fair load on the transformer, the primary current may be calculated on the assumption that the permeability is constant, without much error. But when there is no load, or small load on the transformer, it is necessary to know the law connecting A and I. Everybody who has studied this subject takes A in an unloaded transformer as being N_1C_1. Now, in reality, this is an assumption that there are absolutely no eddy currents; but as there are always eddy currents, however finely the iron may be divided, and even small eddy currents produce great effects upon C_1, the magnetic law which has been deduced from experiments on this assumption must be quite untrue. Taking eddy currents effect as represented by a circuit (n, r) with no magnetic leakage; taking as our magnetic law that when $I=g\sigma\sin x$,

$$A=g(\sin x-b\sin 3x+m\sin 5x).$$

If V is a simple sine function of the time, I is so also with very great accuracy, but not perfect accuracy. Assuming that I is a simple sine function, the neglected terms in V may be calculated; this serves no useful purpose, so far as I can see at present, as they are so insignificant. The only problem of importance is really the calculation of C_1, assuming that with great, but not perfect, accuracy V has the value $V_0\sin kt$. Our equations are $V=R_1C_1+N_1\theta I$ and $0=rc+n0$ I, and hence $N_1V_1/R_1=A+q\theta I$, where $A=N_1C_1+nc$ and $q=N_1^2/R_1+n^2/r$. Now n^2/r is negligible in comparison with N_1^2/R_1 in transformers, and we may take $q=N_1^2/R_1$. Hence $-I=(V_0/N_1k)\cos kt$ very nearly, and if $e=n^2\sigma k/r$, being called the eddy current effect, f being the hysteresis term,

$$C_1=(V_0/N_1^2\sigma k)\{\sqrt{(1+2e\sin f+e^2)}\sin[kt-90+\tan^{-1}(\tan f+\frac{e}{\cos f})]-b\cos 3kt-m\cos 5kt\}. \quad . \quad . \quad . \quad (4)$$

We see that the effect of eddy currents without hysteresis is to increase the amplitude of the fundamental term in C_1, and to produce a lead of $90°-\cot^{-1}e$, whereas the effect of hysteresis without eddy currents is to keep the amplitude unaltered, and to produce a lead f. If f is put equal to 0, that is if we assume no hysteresis, we obtain results which seem to be in accordance with such experimental observations as have yet been made.

The effective current C′ (if V′ is the effective voltage) with constant permeability is $V'/N^2\sigma k$; with hysteresis (or with no hysteresis but some saturation of the iron) but no eddy currents, $C'=1{\cdot}02\,V'/N^2\sigma k$, taking b as $0{\cdot}2$; with eddy currents and hysteresis $C'=V'\sqrt{(1{\cdot}04+2e\sin f+e^2)}/N^2\sigma k$.

The average power given to the choking coil or average value of VC is $V'C'\dfrac{e+\sin f}{1+e^2+2e\sin f}$, neglecting the small terms due to b and m.

Probably, in transformers there are always traces of the term in $3kt$ and the higher harmonics in both V and I, but they certainly must exist in either V or I, whether the transformer is loaded or unloaded. In the loaded transformer, magnetic leakage causes considerable diminution in the higher harmonics of I, and this may increase them in V.

It seems that in a choking coil with a finely-divided iron core, we have found what has been long looked for, a method of increasing frequency by mere magnetic means. A condenser shunting a non-inductive part of the circuit would receive currents in which the higher harmonics would be greatly magnified in importance. To show the magnitude of the terms in (4) I will take the above-mentioned 1,500-watt transformer, in which $q_0=7783$. Taking $f=0$ or no hysteresis, the power wasted in eddy currents being $n^2V_0^2/2rN_1^2$, let this be 40 watts; then $n^2/r=2{\cdot}1168$ when $V=2{,}828$. The eddy current coil therefore which would replace all the eddy current circuits is a coil of two turns whose resistance is about 1·9 ohms, short circuited on itself.

$e=0{\cdot}38$ if $k=600$. Assuming constant permeability and no eddy currents and no hysteresis $C_1=0{\cdot}07398\sin(kt-90°)$, with some saturation and eddy currents but no hysteresis

$$C_1=0{\cdot}07911\sin(kt-69°{\cdot}2)-0{\cdot}014796\cos 3kt-0{\cdot}003695\cos 5kt,$$

I have taken $b=0{\cdot}2$ and $m=0{\cdot}05$.

The primary potential difference V is never a simple sine function of the time. Besides the important term in $\sin kt$ there are small terms of higher frequency, and at least one term of lower frequency equal to the number of turns of the armature per second. The tendency of the forces acting on coils in series on an armature is to produce greater dissonance at greater loads; but it may be assumed that in good machines the fastenings are sufficiently rigid, and the coils and pole pieces so nearly alike that there is always very little dissonance.

The primary potential difference, instead of being $2828\sin 600$ in the above case, may be

$$V=100\sin 20t+2823\sin 600t+200\sin 1800t,$$

the effective potential difference, as measured by a voltmeter, being the same in the two cases. The induction, if there is no magnetic leakage, will be

$$-I=(N_1/R_1q)(5\cos 20t+4{\cdot}7\cos 600t+0{\cdot}11\cos 1800t),$$

the term which was so insignificant, which had only 1/800th of the importance of the most important term in practically estimating the

* [*Added April* 29, 1892.—I have often urged the importance of the consideration of the want of uniformity of induction in the iron; but even in February last, when I brought it before a meeting of the Institution of Electrical Engineers, it was looked upon as unimportant, and I had made no calculations which would enable me to prove its importance. The calculations of Prof. J. J. Thomson concerning the eddy currents in thin plates, published in *The Electrician* of April 8, 1892, place the matter beyond doubt.]

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volts, is now greater than what is usually taken to be the greatest term when we come to deal with the actual induction. Magnetic leakage will not much affect this condition of things, but it will greatly diminish the importance of the higher harmonics.

When experimenters say that they keep the primary volts constant, they mean that they keep the effective primary volts constant. It is obvious from the above considerations that different methods of keeping effective volts constant will produce very different kinds of induction. The effects produced by an exciting current in a choking coil or unloaded transformer are evidently very complicated. Let the dynamo have a perfectly pure simple harmonic law of electromotive force; we have seen that even when no hysteresis is assumed, the current will possess large harmonics and the induction possesses corresponding harmonics. The energy wasted in the creation of these harmonics may be called "hysteresis" loss, but it cannot be altogether the same as the hysteresis loss in slowly-performed cycles of magnetisation; it will be different if the dynamo does not follow a simple harmonic law in its electromotive force, and the apportioning of the small higher harmonics to the primary voltage and to the induction must greatly depend upon the self-induction of the dynamo machine.

POST OFFICE TELEPHONE INSTRUCTIONS.

The following circular (E. 130) recently issued from the Engineer-in-Chief's office of the General Post Office may be of interest:—

Telephone Circuits.

The extended use of telephones by the department, especially in substitution for A. B. C. instruments, appears to call for the issue of more definite instructions than have hitherto been given with regard to the arrangement of telephone lines. The following rules have therefore been drawn up:—

1. All direct telephone circuits which have line resistances of less than 200ω are to be worked without relays.

2. A departmental telephone circuit serving sub-offices may generally be "single-wire" if fairly free from induction disturbance; but only under exceptional circumstances should single-wire circuits be granted to private renters.

3. It is often difficult at out-of-the-way places to secure good earth for single wires, and it has become necessary therefore to recognise that an "earth" may have an appreciable resistance; but every effort should be made to ensure that this does not exceed the limit of 10 ohms laid down.

4. On double-wire circuits, where there are more than two telephones in circuit, the "bridge" system is to be generally employed. On single-wire circuits, where there are more than two telephones in circuit, the "leak" system is to be adopted.

5. The "bridge" and "leak" systems have the following advantages:—

(*a*) A disconnection in one telephone does not prevent the others from communicating;

(*b*) The electro-magnets not being in the direct circuit, the speaking efficiency of the whole line is not materially affected by the number of offices; and

(*c*) Bells without relays can generally be used.

6. When, on a single-wire circuit, an intermediate office is off the main line, and has to be reached by a branch, it is necessary to have only a single wire (not a loop) for the branch. In cases where the branch is so short that only a leading-in wire is required the same rule holds good. The same principle applies also to double-wire circuits, two wires (one from each of the main line wires) being used for each branch. It may be noted that this does not apply at offices where intermediate switches are to be fixed.

7. Bells without relays:—

(*a*) These may be applied in *all* cases where there are only *three telephones* upon a circuit, provided that the joint resistance of the ringing circuit from any telephone does not exceed 150ω.

(*b*) They may also be used with *any number* of offices on a circuit, provided that the line resistances between the offices are fairly uniform and do not exceed (say) 20ω in each section. When bells are not worked from a relay, their coils should invariably be joined in series.

8. As the current divides in inverse ratio to the resistance, it is desirable, for ringing purposes, that the several arms of a circuit shall not be very unequal. In the case of a "three-office" circuit balancing resistances should be inserted if necessary in both the shorter branches. The resistance coils should be so connected as to be out of circuit both for speaking and for the outgoing ringing current (Figs. 1 and 2). The advantage of this arrangement is that the introduced resistances do not involve any increase of battery power, although the ringing currents received by each office from either of the others are practically equalised.

9. Where there are more than three offices upon a circuit:—

(*a*) If the resistance between any one office and the next is small (say not more than 20ω) no balancing resistances need be used and bells will suffice.

(*b*) If the resistance between the two or more intermediate offices is small and the resistance of one or more of the terminal arms is considerable, then *all* the terminal arms should be balanced so that each has approximately the same resistance. It should be borne in mind that on the "bridge" or "leak" system, the *second* office at each end is practically terminal as well as the first, and must not for the purposes of this rule be considered "intermediate." Thus, *all* offices on a circuit with four instruments are "terminal" (Fig. 3.)

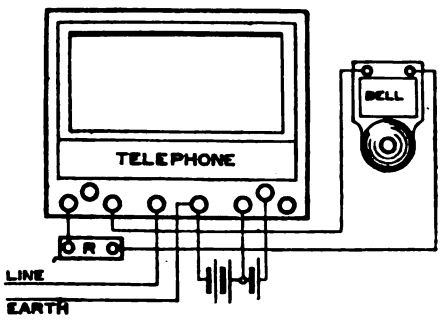

Fig. 1.

(*c*) When the resistance between the intermediate offices exceeds 50ω, so that it must be taken into account, it is necessary to use a high-resistance (1,000ω) relay at each office. The line resistances of an ordinary telephone circuit are generally so small in comparison with 1,000ω that they need not be taken into account when this relay is used; and, as the relay is made more sensitive so that the working current is reduced from 16 milliamperes to seven, the introduction of the high resistance is to some extent compensated.

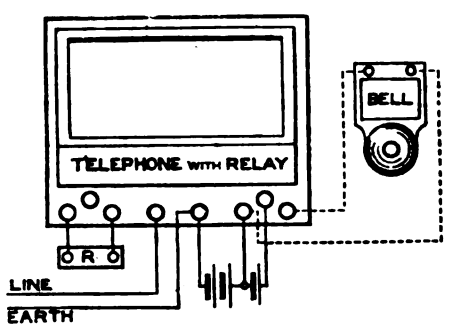

Fig. 2.

High resistance relays will now be supplied on requisition. They are ordinary telephone relays specially wound to 1,000ω and may be had either mounted or unmounted, like the 100ω relays.

(*d*) If, with 1,000ω relays, the resistance of one terminal arm, in a case where more than three offices are in circuit, should be more than 150ω in excess of that of any other terminal arm, it is advisable to insert balancing resistances until the resistance of each arm of the circuit is within 50ω of the resistance of the arm in question.

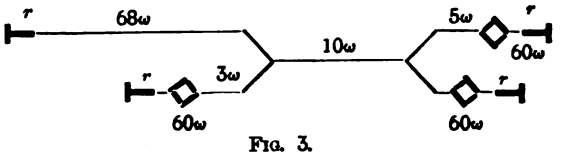

Fig. 3.

10. The battery-power must be so regulated that each office may receive the standard working current according to the following scale:—

Bells (100ω) ...	...	...	...	25 milliamperes.
Relays (100ω)	...	...	...	16 ,,
Relays (1,000ω)	...	...	...	7 ,,

Calculation of the Battery Power.

11. (*a*). It must be remembered that the balancing resistance at the calling office is not in circuit. (*b*.) Care must be taken to ensure that the office *least* favourably situated with regard to the calling offices will get sufficient current. (*c*.) On single wire circuits the resistance of each earth may be assumed to be 10 ohms (unless, of course, it is known to be greater). (*d*.) The electromotive force of a Leclanché cell may be taken as 1·2 volt and its resistance as 4 ohms.

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12. For offices where not more than nine cells are required No. 1 size should be used, but where more than nine cells must be fixed, then two cells of No. 1 size should be used and the remainder of No. 3 size. No. 1 size cells are fitted in boxes of 2, 3, 4 and 5; No. 3 size in 6, 8, and 10.

13. The method of calculating the battery power will be best understood from the following example, showing the complete calculations (with remarks) for a four-office circuit of high resistance with 1,000ω relays and no balancing resistances. (Fig. 4.)

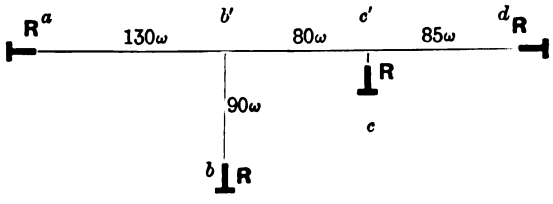

Fig. 4.

[If the resistance of the arm $a\ b'$ or $b\ b'$ exceeded 150ω, balancing resistances would have to be applied under paragraph 9 (d), because c (with an arm of no resistance, except 10ω for earth, which is negligible) is practically as much a terminal office as d.]

(i.) Ringing power for a:—

Joint resistance $c\ c'$ and $c'\ d = \frac{1010 \times 1095}{1010+1095} = 525$ (say 520^{ω}).

Total resistance of arm $b'\ c\ d = 520^{\omega} + 80^{\omega} = 600^{\omega}$ . . . (1).

Joint resistance of $b'\ b$, and $b'\ c\ d = \frac{1100 \times 600}{1100+600} = 388^{\omega}$.

Total resistance of ringing circuit from $a = 388 + 140 = 528^{\omega}$ (2).

Now, at b' the current from a will divide in the ratio of 600 to b and 1100 to c and d; that is, c and d will get $\frac{11}{17}$ of the current sent from a. Of this, c and d will get respectively in the proportion of 1095 and 1000; that is, d will get $\frac{1000}{2095}$ of $\frac{11}{17}$ of the current sent from a; and this, for a 1000ω relay, must be not less than 7 milliamperes; therefore the total current from a must be

$$7 \times \frac{17}{11} \times \frac{2095}{1000} = \frac{49861}{2200} = 22 \text{ milliamperes};$$

and (as E = C R, and R in this case is 528^{ω}) the electromotive force required at a is

$$E = \frac{22 \times 528}{1000} = 11{\cdot}716 \text{ volts.}$$

It follows that the battery power at a should be at least 10 Leclanché cells; but as the resistance of the battery is not taken into account, and the 10 cells do not give much margin, 11 cells might be fixed in this case. [In determining the power for b, c, and d, a more practical method (with simply approximate figures) will be followed.]

(ii.) Ringing power for b:—

We know from (1) that the total resistance $b'\ c\ d$, is 600ω.

Joint resistance $b'\ d$ and $b'\ a = \frac{600 \times 1140}{600+1140} = 393^{\omega}$. (3).

Adding 100ω for resistance $b'\ b$ we have,

Total resistance of circuit from $b = 493^{\omega}$. . . (4).

Now, each of the other offices is to get 7 milliamperes; b must therefore send 21 milliamperes.

Therefore, E.M.F. required at $b = \frac{21 \times 493}{1000} = 10{\cdot}353$ volts or 9 Leclanché cells. [The closer calculation would have brought the same result].

(iii.) Ringing power for c:—

First determine the joint resistance of $b'\ a$ (1140ω), and $b'\ b$ (1100ω). These two arms are so nearly alike that we may safely assume their joint resistance to be their sum divided by 4, which is 560ω.

And therefore total resistance of arm $c'\ b\ a = 560^{\omega} + 80^{\omega} = 640^{\omega}$ (5).

Joint resistance of $c'\ a\ b$, and $c'\ d = \frac{640 \times 1095}{640+1095} = 403^{\omega}$. (6).

= total resistance of circuit from c.

Therefore E.M.F. required at $c = \frac{21 \times 403}{1000} = 8{\cdot}463$ volts. 8 Leclanché cells should therefore be taken.

(iv.) Ringing power for d:—

The resistance of $c'\ b\ a$ is known (5) to be 640ω. Therefore the joint resistance from $c' = \frac{640 \times 1010}{640+1010} = \frac{16000}{41} = 391^{\omega}$ (say 390^{ω}) . (7).

And (adding the resistance of section $c'\ d$) the total resistance from $d = 485^{\omega}$ which is so close to that from b (493^{ω}, *see* 4) that we may at once assume the power to be the same, namely, nine Leclanché cells.

14. In the following illustrative diagrams ⊣ represents a telephone with direct bell; ⊣ a telephone with 100ω relay; and ⊣ a telephone with 1000ω relay.

Ordinary Three-Office Circuit.

(a.) *Single wire.*

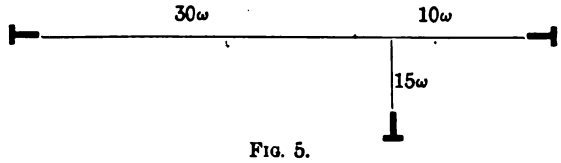

Fig. 5.

(b.) *Double wire.*

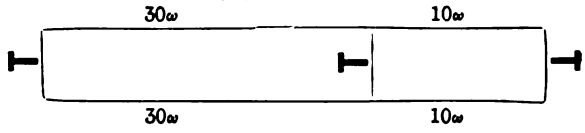

Fig. 6.

Three-Office Circuit with Relays and Balancing Resistances.

(c.) *Single wire.*

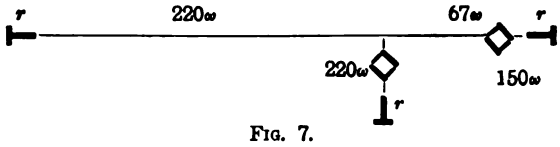

Fig. 7.

(d.) *Double wire.*

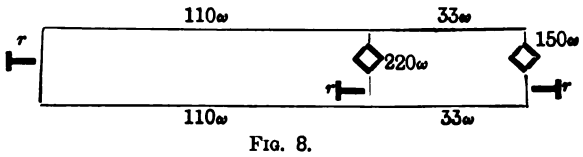

Fig. 8.

[If the resistances had been considerably lower, relays would not have been used. *See* para. 7.]

(e.) *Ordinary Four-Office Circuit.*

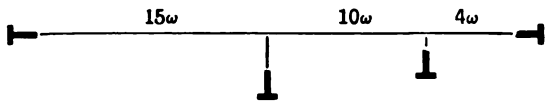

Fig. 9.

[No section exceeds 20^{ω}. *See* para. 9*a*.]

(f.) *Four-Office Circuit with Balancing Resistances and Relays.*

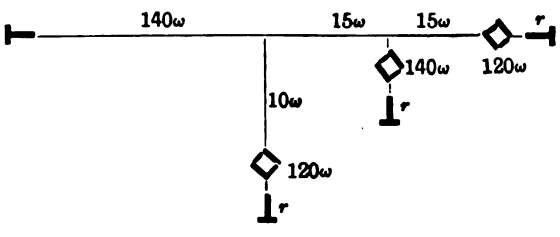

Fig. 10.

[The several arms are balanced up to 140ω, 130ω, 140ω, and 135ω. *See* para. 9*b*.]

(g.) *Multiple-Office Circuit with 1000ω Relays.*

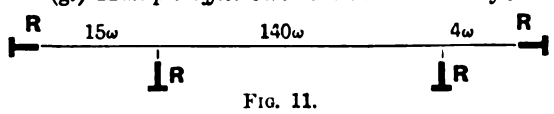

Fig. 11.

[This arrangement is in accordance with 9*c*.]

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(h.) *Multiple-Office Circuit with 1000ω Relays and Balancing Resistances.*

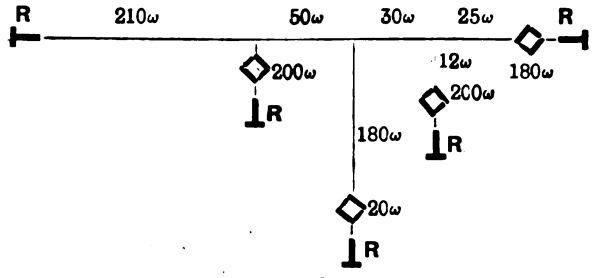

FIG. 12.

[In this case one terminal arm (220ω with earth) is more than 150ω in excess of any of the other three (which are 10, 22, and 35). All are therefore approximately balanced.]

15. The diagrams on works estimates for telephone circuits should, in all cases, be figured as above with the resistance of each section of the line.

16. On some departmental circuits and at coastguard stations it is often desirable that there shall be an indication of the outgoing current and also of the incoming current independently of the bell or relay. It is therefore proposed for such circuits to issue "tele-

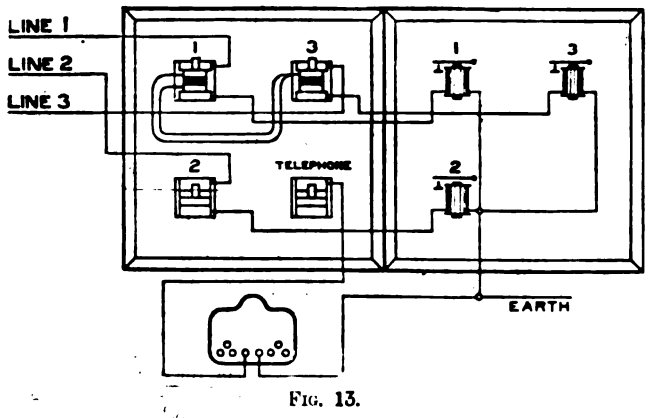

FIG. 13.

phone galvanometers." These will probably be non-polarised magnetic indicators wound to a resistance of 3,000 ohms, and they will be connected (in bridge or leak) direct on the lines so as to be always in circuit. This will necessitate a slight increase in ringing-battery power. It may be taken that for circuits fitted with 1,000-ohm relays one-third more current should be allowed to each office; and where bells or 100-ohm relays are used the increase will generally be very slight indeed, depending, of course, partly upon the balancing resistances that may be used.

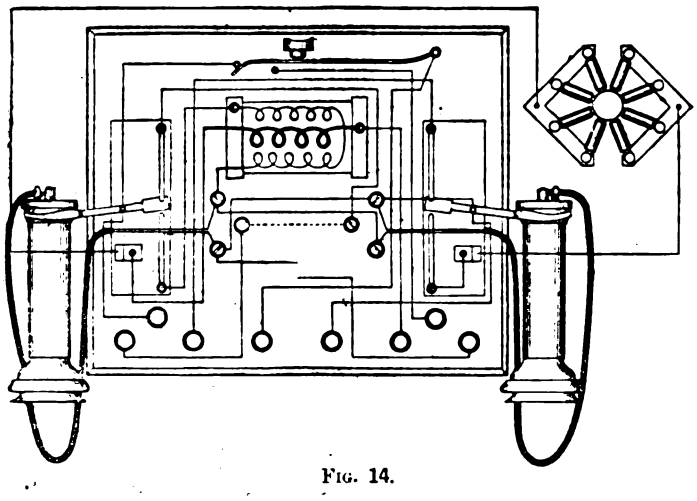

FIG. 14.

17. In arranging departmental circuits for the transaction of public business it is often convenient to group them into a small exchange; in which case the connections should be so arranged that the several stations may either be placed in communication with one another or speak direct to the exchange. The connections shown in the subjoined diagram of a single wire system are so arranged that when two circuits are put through the indicator of only one line is left in "leak. (Figs. 13 and 14.)

At one end of the flexible cord the two conductors are attached one to each side of the peg, and at the other end *both* conductors are connected to the *upper* side of the peg.

18. As such departmental exchanges are likely to include circuits of very various resistances, which (from the nature of the circumstances) cannot be compensated for, it may be taken as a general rule that, wherever any circuit on such an exchange embraces two offices, the whole system should be fitted with 1000ω relays; and 1000ω non-polarised indicators should be fixed at the exchange.

19. Where only two circuits are led into a "central" office it is not necessary to fit an exchange switch with pegs. A "bridge intermediate switch," which is simpler and much cheaper, will suffice.

20. The attention of telephone operators should be directed to the fact that in case of failure of their microphone (which is indicated by their being able to hear distinctly, while they cannot be heard) they should endeavour to speak through the receiver.

21. The question as to whether more than one telephone is wanted at the exchange will be best determined by local circumstances; but it should be recognised that, to safeguard against breakdown of the exchange system owing to a fault in the exchange telephone, two telephones should be fitted when more than four circuits are connected.

II.—Post Office Telephone.

22. A new telephone manufactured by the Department is now being issued. This instrument consists of the Gower-Bell transmitting arrangement of carbon pencils mounted on a smaller diaphragm without a mouthpiece, and two Bell telephones which serve as receivers in place of the Gower-Bell receiver and tubes.

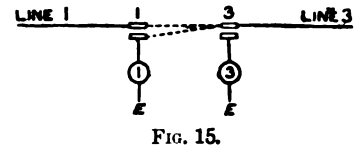

FIG. 15.

23. Each Bell receiver is wound to a resistance of 120 ohms, approximately, and the two are connected in parallel circuit.

The resistances of the new induction coils are:—

Primary	5ω
Secondary	150ω

24. The connections are uniform with those of the Universal Gower-Bell Telephone, and they are arranged to be used with or without a relay inside the case.

Other paragraphs relating to requisitions and other purely departmental matters follow.

BRITISH ASSOCIATION.

DISCUSSION ON A NATIONAL PHYSICAL LABORATORY.

A discussion upon the subject of the need for a National Physical Laboratory was held in Section A on Monday, August 8th. Prior to the actual opening of the discussion by Prof. Oliver J. Lodge, the President (Prof. Arthur Schuster) said Prof. Schoute had a Paper to read which had some relation to the subject, as it showed what had been done in another place in a direction similar to that which Dr. Lodge proposed should be taken in this country.

* Remarks revised by Speakers.

Prof. P. H. SCHOUTE then read a Paper on "The Construction of the New Physical Laboratory at Groningen, Holland." He said two special points had been kept in view in the design and construction of the buildings he would describe, these being that they should be thoroughly fitted both for instruction and for investigation. With regard to design, there was a class-room fitted up for 100 students; separate rooms were provided for instruments, and there were special laboratories on the ground floor for young students. In the construction the things chiefly aimed at had been the avoidance of disturbance from traffic and interruption due to sunlight, a good foundation and the absence of iron. To eliminate as far as possible all effects of vibration, the instruments were so placed as to be quite independent of the floors of the fabric itself. A solid stone foundation was laid, which occupied very nearly the whole of the floor space, but was clear of the walls on every side. Upon this foundation were erected a number of stone piers. The floor was supported on beams fixed to the walls, but over the piers were movable slabs one metre square, which could be taken up so as to allow of the instruments being placed directly upon the piers. An instrument could thus be placed in any part of the room, and yet be almost entirely free from any disturbing effects.

The PRESIDENT bespoke the thanks of the Section for Prof. Schoute's Paper, and said they would pass on to the discussion of a similar project

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for this country. Prof. Lodge, President of the Section last year, in his presidential address, suggested the establishment of a National Physical Observatory, and it might be well to follow up that suggestion with a short discussion this year, so that they might know how far the different members of the Section were really agreed as to the advisability of facilitating the institution of any such observatory. Last year a committee was appointed to report on the subject, and the report of the committee would be taken in conjunction with Prof. Lodge's remarks.

* Prof. LODGE: The report is merely a formal thing, because the committee, as a matter of fact, have not met. The committee was appointed at Cardiff, and a circular was sent round asking for information and correspondence, and a certain number of answers were obtained; but on the whole it was thought wiser to wait for a further discussion before anything was seriously undertaken. If anything is going to be done it is not going to be done in five minutes, possibly not in five years, and there is not any special hurry. This is a good opportunity to discuss the matter, especially as we have the presence here of several Continental philosophers. The idea I wanted to bring before the Section is the question of the advisability of establishing a National Physical Laboratory on the lines of some institutions abroad, and on the lines of the Greenwich Observatory in these islands. So much work is done in this country which is done in Universities and by amateurs which might more easily and with more economy of brain power be conducted by a permanent staff, a staff established through a regular National Laboratory, under the lead, directly, of some eminent man of science, no doubt, but also under the guidance of a committee of the Royal Society, as the Greenwich and Kew Observatories are now carried on. But there is not the remotest chance of carrying conviction to any British Government unless we have the support of Lord Kelvin. A science in its infancy may be and must be grappled with by the scientific amateur, or at any rate by the isolated individual. To explore new and savage territory heavily armed troops are unnecessary and inefficient. As our President told us, a heavy weight of learning is an encumbrance, and we look to the free lances and skirmishers of science for the striking out of fresh fields of investigation. But as a science becomes adult, as it reaches the stage when minute accuracy becomes possible and desirable, the labours of the amateur in those branches get increasingly difficult and inefficacious. A great weight of learning is now no longer an impediment, but an essential; heavy armed troops can now fulfil their proper function, and we have need, even, of the artillery or great guns of science. But the greatest men of science, as of every other department, are and must be few; their proper function is that of generals, of commanders. There is in this country too much tendency to keep everyone in the ranks, or at most to make him a corporal, with a command of four or five assistants, whom he must train himself. If he undertakes investigation he must do it in the intervals of teaching, sometimes of examining; and even when circumstances relieve him from that fatigue drill he must always work essentially as an amateur, taking up and dropping investigations according as his interest in them waxes or wanes, and leaving nothing to a successor but example and, perhaps, inspiration.

Now this free and amateur way of cultivating science has its advantages. Our President maintained this, and I not only admit it but strongly feel the truth of the statement. It has its advantages; but it has also some disadvantages. Some men can and always will work best in that way: others could do better as heads of a great establishment with an organised staff and thorough equipment. For these latter men, so far as physics is concerned, we have no provision in England. Abroad it is otherwise; but I shall leave it to others to speak of abroad, I elect to speak only of the British Isles. But in the British Isles other subjects are not so ill provided as is physics. Astronomy has had the Greenwich Observatory for centuries, and by private munificence or Government endowment there are several other observatories. What I may speak of vaguely as the observing or the natural history sciences have that great institution the British Museum in its various departments, and for biology specially those sumptuous new quarters at South Kensington have been erected. For geology there is the well-equipped staff of the Geological Survey, and so on. But for physics, what is there, except the old universities, the new university colleges, and a teaching college at South Kensington? Of the work done by such bodies it is impossible to speak too highly. A great deal they do, and will always, I hope, continue to do, in the direction of pure research; but I urge that there are many, very many, investigations for which they are unsuitable, and which they can only undertake at disproportionate labour and sacrifice. If Greenwich Observatory and the Nautical Almanack did not exist, if the observation and reduction of transits had to be executed by amateur observers at fitful intervals, how great would be the waste of power, and how painfully feeble the result! The universities and colleges have plenty of work lying to their hand. They stand intermediate between the amateur on the one hand and the highly-equipped Reichsanstalt and Bureau des Poids et Mésures or National Physical Laboratory, on the other. There is room for all three arms of the service—the cavalry, the infantry and the artillery—and one cannot satisfactorily perform the work proper to the others. There is much work for which it would be disgraceful to use our greatest men. If it is a relaxation to Lord Rayleigh to weigh hydrogen for a few years, well and good; but it is work more suited to the staff of a National Laboratory under his direction. A great number of precise and accurate observations can only be carried out by the patient and continuous labour of trained and competent observers for a year or two. For all, or for many, such trained and competent observers, places would be found in the National Laboratory. They need not be men of genius; they must be men of care, of precision, of system, and of ability. Such men are not, indeed, common; but there must be hundreds of them for one great man of genius. Isolated as they are now, they often do not know in what direction to work. Though not, perhaps, specially original or brilliant, they are sound and thorough workers, but they want a leader. Utilise these men, and do not waste them. Establish a great National Physical Laboratory, where congenial work can be found for them, and there they will gradually find their level, whether it be high or low.

Of the work that should go on in such an institution much might be said if the matter were seriously considered; but by way of reminder I may indicate the types of work which everyone will admit to be suitable; and first of all, the place which has done work most allied to the sort I contemplate has been the Cavendish Laboratory at Cambridge. There Lord Rayleigh spun the ohm, there Mr. Glazebrook watches and compares the standards, there much other work of high accuracy is carried on by the men reared in that splendid University. Here, again, Prof. Tait squeezed thermometers for the "Challenger" expedition, and incidentally worked out some of the properties of water. Nearly all that class of work might appropriately have been conducted in the National Laboratory. Fresh determination of the ohm, measures of V, of standard electrochemical equivalents, of J or the specific heat of water, of the gravitation constant; all these things, now going on in various parts of the island, are more appropriate to a central or Government institution, with every possible appliance and aid to accuracy, with absolute standards ready for use, with rooms which can be set aside to a special purpose for several years, or, if necessary, for several centuries, and a staff of skilled assistants, one or two of whom can be detailed off to conduct each investigation to a full and satisfactory conclusion. An investigation in progress need not then be dropped by reason of lapse of interest on the part of the investigator, or his decease or removal. The staff will be immortal, and any research determined on and ordered by the head or by the governing committee may go on for precisely as long as their judgment decides to be right. Nearly all the work of Regnault was carried out under circumstances something like those I advocate, and to an amateur such work would have been practically impossible. The apparently simple operation of filling and weighing a column of quicksilver and measuring its resistance per cubic centimetre with accuracy is a thing of surprising difficulty. Not only could no amateur hope to do it, but it eluded Lord Rayleigh himself. No one without access to a standard meter and a standard kilogramme could attempt it, and a re-determination of the density of water would be necessary before the contents of the tube could be measured. After that the difficulties would begin. Prof. von Helmholtz, Dr. Lindeck, and the staff of the Reichsanstalt, have done something towards it; M. Guilleaume and others, at Paris, have attacked another part; and the workers in the Cavendish Laboratory, and many parts of the world, a third part; but even with all that heavy artillery the thing has not been yet accomplished.

Classes of work appropriate to the National Laboratory are—(1) extremely accurate determinations of fundamental quantities, like V, the ohm, &c.; (2) determinations of physical constants and properties of materials (what I may call Regnault work); (3) maintenance of standards and issue or verification of stamped and certified copies of the same for scientific or industrial use; (4) continuous record of certain phenomena, supplementing but not necessarily interfering with the similar work of Greenwich and Kew; (5) undertaking certain determinate lines of research, especially such as are likely to last many years or centuries, and carrying them to a definite conclusion; secular experiments on the properties of solids, such as have been begun at Glasgow, but nowhere else that I am aware of. Pioneering work, such work as that of Faraday, and others living who could readily be mentioned, the National Laboratory could not usefully undertake; it would be devoted to the dryer and more thoroughly ascertained facts of science, and almost entirely to quantitative research. Work of genius, again, though quantitative, like that of Michelson, it would be too much to expect from any institution, though it might sometimes be forthcoming; but much of the careful and laborious work now done by amateurs might be undertaken at such a laboratory if it existed, and, merely by way of example, I have taken the last four volumes of the *Philosophical Transactions* to see what Papers may be suggested as falling under this category. [Here Dr. Lodge gave a list of Papers.]

My idea is that amateurs would, as at present, start lines of research, and carry them on until they became unwieldy; but that at that stage, instead of dropping them, or, as we now do, leaving them for the Continent to continue, our own National Laboratory should take them up and incorporate them with the regular work of its staff. At Cardiff I urged this subject in my address. But few of the brilliant assemblage attracted by this city were there present, and so I venture on a few extracts from last year's volume:—"If such an establishment were likely to weaken the sinews of private enterprise and individual research it should be strenuously opposed; but, in my opinion, it would have the opposite effect, by relieving the private worker of much which he can only undertake with great difficulty, sacrifice, and expense. . . . Long continued consecutive observations may be made by a leader of science, as functions may be tabulated by an eminent mathematician; but, if the work can be done almost equally well (some would say better) by a professional observer or computator, how great an economy results! Now all this applies equally to physics. The ohm has been determined with 4-figure, perhaps with 5-figure accuracy; but, think of the list of eminent men to whose severe personal labour we owe this result, and ask if the spoil is worth the cost. Perhaps in this case it is, as a specimen of a well-conducted determination. We must have a few specimens, and our leaders must show us the way to do things. But let us not continue to use them for such purposes much longer. The quest of fifth or sixth decimal is a very legitimate, and may become a very absorbing quest, but there are plenty of the rank and file who can undertake it if properly generaled and led; not as isolated individuals, but as workers in a National Laboratory under a competent head and a governing committee. By this means work far greater in quantity, and in the long run more exact in quality, can be turned out by patient and conscientious labour without much genius, by the gradual improvement of instrumental means, by the skill acquired by practice, and by the steady drudgery of routine. . . . The Meteorological and Magnetic Observatory at Kew (in the inauguration

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of which this Association took so large a part), is a step, and some useful quantitative work is done there. The new Electrical Standardising Laboratory of the Board of Trade is another and, in some respects, perhaps, a still closer approximation to the kind of thing I advocate But what I want to see is a much larger establishment, erected on the most suitable site, limited by no specialty of aim, nor by the demands of the commercial world, furnished with all appropriate appliances to be amended and added to as time goes on and experience grows, and invested with all the dignity and permanence of a national institution : a physical observatory, in fact, precisely comparable with the Greenwich Observatory, and aiming at the very highest quantitative work in all departments of physical science. That the arts would be benefited may be assumed without proof. It is largely the necessity of engineers that hasi nspired the amount of accuracy in electrical matters already attained. The work and appliances of the mechanical engineer eclipse the present achievements of the physicist in point of accuracy, and it is by the aid of the mechanician and optician that precision even in astronomy has reached so high a stage. There is no reason why physical determinations should be conducted in an amateur fashion, with comparatively imperfect instruments, as at present they mostly are. Discoveries lie along the path of extreme accuracy, and they will turn up in the most unexpected way. . . . . In a national observatory accuracy should be the one great end—the utmost accuracy in every determination that is decided on and made. Only one thing should be more thought of than the fifth significant figure, and that is the sixth. The consequences flowing from the result may safely be left ; such as are not obvious at once will distil themselves out in time. And the great army of outside physicists, assured of the good work being done at headquarters, will (to speak again in astronomical parable) cease from peddling with taking transits or altitudes, and will be free to discover comets, to invent the spectroscope, to watch solar phenomena, to chemically analyse the stars, to devise celestial photography, and to elaborate still more celestial theories, all of which novelties may in their maturity be handed over to the National Observatory, to be henceforth incorporated with and made part of its routine life ; leaving the advance guard and skirmishers free to explore fresh territory, secure in the knowledge that what they have acquired will be properly surveyed, mapped and utilised without further attention from them. . . . . I have spoken of the work of the National Laboratory as devoted to accuracy. It is hardly necessary to say that the laboratory will be also the natural custodian of our standards, in a state fit for use and for comparison with copies sent to be certified. Else, perhaps, some day our standard ohm may be buried in a brick wall at Westminster, and no one living may be able to recall precisely where it is. But in addition to these main functions there is that other : the undertaking of secular experiments on the properties of materials – the elasticity of metals, for instance ; the effect of time on molecular arrangement ; the influence of long exposure to light, or to heat, or to mechanical vibration, or to other physical agents. Does the permeability of soft iron decay with age, by reason of the gradual cessation of its amperian currents ? Do gases cool themselves when adiabatically preserved, by reason of imperfect elasticity or too many degrees of freedom of their molecules ? Unlikely, but not impossible. Do thermo-electric properties alter with time ? And a multitude of other experiments which appear specially applicable to substances in the solid state—a state which is more complicated, and has been less investigated, than either the liquid or the gaseous, a state in which time and past history play an important part. Upon whichever of these long researches we may decide to enter, a national laboratory, with permanent traditions and a continuous life, is undoubtedly the only appropriate place. At such a place as Glasgow the exceptional magnitude of a present occupant may, indeed, inspire sufficient piety in a successor to secure the continuance of what has been there begun ; but in most college laboratories, under conditions of migration, interregnum, and a new *régime*, continuity of investigation is hopeless. I have, at any rate, said enough to indicate the kind of work for which the establishment of a well-furnished laboratory, with fully equipped staff, is desirable; and I do not think that we, as a nation, shall be taking our proper share of the highest scientific work of the world until such an institution is started on its career."

* Mr. R. T. GLAZEBROOK : I presume that I have been asked to speak to you on what Dr. Lodge has so carefully brought before us mainly because it is my privilege to be very closely connected with that laboratory in which, he has been kind enough to say, very much work that would naturally be undertaken by a National Standardising Laboratory has been done during the past few years. Thanks to Lord Rayleigh and that unequalled series of investigations he conducted, the name of the Cavendish Laboratory will ever be inseparably connected with electrical standards and their accurate determination. He has left it to us who are now at the laboratory still connected with the place, to endeavour to carry on the work which he commenced there, and to maintain the high traditions he established. Dr. Lodge has told us so clearly and so plainly what are the main pieces of work that might at present be undertaken by such a laboratory, that there is really not very much for me to say. At the same time it may be interesting if I call attention to some few points of detail of which I have had some practical experience in the last few years —points of detail connected with experiments which might equally well have gone on in some large National Laboratory. Suppose we take as an instance the important question to which Dr. Lodge has referred, of electrical units. As you all know, practically up to the present the old B.A. units of this Association have been for practical purposes the national standards of electrical resistance. Now, in connection with these standards of resistance there are two pieces of important work, both of which, in my mind, might be and ought to be performed by some large national establishment. There is, first of all, the testing of coils and issuing of certificates of resistance, and of other electrical standards, E.M.F. or current. For that there is a great and increasing demand. I feel sure that it would be desirable and useful if the number of coils tested were far larger than any I could undertake to deal with. Coils do come down to me in very large numbers at Cambridge ; but I am so much engaged in other work that this work of testing resistance coils or standards can only be carried on at odd moments, a fact which must at times lead to considerable inconvenience and difficulty. It would be otherwise with a National Laboratory. But that is not by any means all or the most important part of the work which would be carried out in such an establishment. It is desirable, in fact of the greatest importance, that the standards we have here should be identical with those which are used in other countries. It is important that we should feel certain that no changes of a secular nature or otherwise are going on in the standards that we adopt. As you are aware from the reports of the Electrical Standards Committee from time to time that investigation is, to a certain extent, carried out. But it wants far more frequent work, far more continuous observation than I can give to it to make quite sure whether there are changes, and what those changes are. It needs also that our standards should be carefully compared with those of other countries. I have had the privilege—thanks to my position as secretary of the Standards Committee—of comparing my resistance standards and standards of E.M.F. with those in use in France, copies of which were sent to me by M. Benoit. But these should have been sent, to my mind, to a National Laboratory, and not to a private individual. I have recently had the pleasure of working with Dr. Lindeck in observations of a similar character. But work like that should have gone on in some National Laboratory, and not have been merely the work of a private person like myself. What I have said with regard to resistance coils applies equally to all other standards. At the Cavendish Laboratory there are standard condensers. They, again, should receive frequent investigation, and in addition to that they need to be in a place where they would be readily and easily accessible to British and foreign physicists. The same remark applies, of course, to all other electrical standards whatever. We hope that the new Laboratory of the Board of Trade, which is being fitted up so carefully at present by Major Cardew, will in part meet the want. But I feel sure that Major Cardew would agree with me, if he were here, that that laboratory is not on anything like a sufficiently large scale to do all, or anything like all, that is required. I have been speaking up to the present about electrical questions, because they are questions with which I have been most intimately connected. But remarks of a similar nature may be made with regard to other physical questions. What would be the position of engineering without the researches of Regnault ? Take again the work, for instance, being done at present in Paris, at the Bureau International. We in England have done nothing in thermometry that is at all comparable with what has been done there by our guest M. Guilleaume. Or consider again secular experiments. As Dr. Lodge has told us, the experiments on the elasticity of wires which Sir William Thomson started in Glasgow will go on long after Lord Kelvin has ceased to be professor there. But that is an exceptional case. I remember an incident in point which concerns myself. When I first commenced work at the Cavendish Laboratory I had the high privilege of being a pupil of Clerk Maxwell. At his suggestion I was anxious to make some observations on the growth of crystals and the optical properties that they might acquire under certain conditions. I went to Maxwell, and discussed with him what I wished to do ; but he said, "You will have to watch those crystals growing for five or six years." I was a young man, and I wanted to write a dissertation for an examination. What was I to do ? The work remained undone. Dr. von Helmholtz is the President of an institution similar to that we have in mind, established first at the expense of Dr. Werner Siemens, and maintained now by the German Government. I trust he will tell us something of the methods of the institution. I have a Paper here giving an account of the results achieved by the institution in the first three years of its existence from 1887 to 1890. It covers a very wide field of research. I need not go through it in detail. The number of assistants in that laboratory, I believe, is nearly 70. and the annual expenditure is a very large sum indeed. Electricity, heat, light and sound are dealt with, and dealt with in a way which to us here in England is amazing. Those of us who have had the opportunity in private conversation of discussing this matter, either with Prof. von Helmholtz himself or his assistants, well know the great value of the work done. I certainly can assure those great German scientists that I have learnt a great deal from their important work. Allow me then, in conclusion, to ask Dr. von Helmholtz to explain to us why it was that such men as Dr. von Werner Siemens and himself considered it a matter of national importance that Germany should have such a laboratory ; what are the methods and principles on which it is conducted ; what are the aims he has set before himself for that laboratory to achieve, and how at present those aims are being carried out.

Prof. VON HELMHOLTZ said it was not necessary that he should speak on the general aspect of the question. It would be sufficient if he gave a short report of the history of the German institution. It happened that at a certain period they had not mechanicians enough to do the work which was needed for several practical and scientific purposes, which depended on the perfect development of electrotechnics. Messrs. Siemens and Halske had swallowed up nearly all their able young mechanicians. There were some very able mechanicians left, but the masters of workshops had no assistants, and, therefore, they complained that they could not produce as many telescopes and measuring instruments as were wanted for the general staff, and the Navy, and so on. Therefore, it was thought necessary by the Government of Prussia that some steps should be taken to assist mechanicians in their work and to make researches which would be of assistance to them. This was the beginning ; but nearly at the same time came the question of electrical units. It was felt that there ought to be a place where electrical standards could be controlled, and where tests could be conducted and the standards of other nations compared. It was Prussia which first undertook this task. Prussia assisted in the building of the great melting stove of Prof. Abbé, the German optician, and Mr. Zeiss

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who was a renowned constructor of microscopes. They had arranged a peculiar melting stove for glass, where they began the preparation of glass for optical purposes. This went on very satisfactorily, and afterwards came other questions concerning glass, for instance about glass used for thermometers, and also the glass used by chemists, because it came out that the glass which was easily melted and easily warped was not sufficiently hard; it dissolved very easily, the surface was altered, and many things could not be made with the glass so treated. It was also proved that in thermometers the stability of the freezing point depended largely on the sort of glass used. There were some glasses which after being heated to 100deg. were a whole degree wrong, whilst there existed glasses where this difference was only one-tenth of a degree. He thought for mercurial thermometers this was the greatest source of insecurity, and if they could get rid of that circumstance and diminish the extent of difference they would get far better measurers of temperature. Therefore the first end was to get the Government to assist the art of mechanics. When they came to consider the question of electrical units it was clear that the scientific part must be combined with the practical part of the institution. This was done, and they now had two large buildings; one was not yet finished, but when it was they would have a complete observatory for scientific purposes. The plan was that this observatory for physics should be purely of a scientific nature, as were observatories for astronomy; that was to say, that there should be no instruction—at least, no systematic teaching; in fact, the directors and officers were to be entirely free from the duty of teaching. The laboratories for natural science had developed very rapidly in Germany, yet at every fresh trial it was found that they were not sufficiently numerous. He had himself built in the course of his life the Geological Laboratory and afterwards a little Physiological Laboratory. When he went to Berlin, there was at first a very small laboratory arranged in the University Building. A splendid laboratory was afterwards built, which was separate from the University. This they found to be too small when it came into practice; they were always wanting improvements, and so it was repeatedly enlarged He had guided those laboratories for a very long period. The Professor who now had charge of them was also occupied in teaching; he had to go every day for one or two hours to the laboratory and speak with the different students and counsel them, and ask them how they got on. Very often he (von Helmholtz) had been obliged to make mathematical investigations for himself privately at home, or aided by students. Therefore his time had been very largely taken up, and he was completely separated from all experimental researches. He could only undertake such experiments as were necessarily not of long duration and required looking after for only a quarter of an hour or so every day. Then the number of instruments in such a laboratory was, of course, limited; it was difficult to keep them back from the students, and as instruments which were used by many people, sometimes people not well instructed, must suffer from such usage, they could never be sure that they were in sufficiently good order to serve for delicate experiments, and it was always necessary to begin anew to find whether the instrument was right before proceeding with an investigation. If a man wished to make delicate experiments and measurements it was needful that he should have the instruments to himself, and that nobody else should be allowed to use the same instruments. A student in these institutions which were used principally for instruction could go on with fundamental scientific researches in the way which was probably the best possible for them; and undoubtedly, and in spite of hindrances, a great deal of scientific research had been carried out in the German universities, and a great many important results had been brought out. But there were some kinds of investigations which could not be done in that way. They could not hope that amateurs, even if they were quite independent in their pecuniary means and in regard to locality and time, would go on with fatiguing and often monotonous investigations for the purpose of discovering even important results. Therefore, they came to the conclusion that it was necessary for some fundamental investigations to be pursued in another way with the aid of Government. It was the Prussian Government which first undertook the work, but it soon became clear that it could not be confined to Prussia alone, and that it was necessary to spread the thing out over the whole of Germany. Therefore, the Empire built and endowed the new institution some four years ago. There were two subdivisions of the institution, one scientific and the other practical, because there were some practical questions which it was important to take into consideration. With regard to this technical and practical grant, they had first a great amount of work with thermometers. He (the speaker) had never thought that such a quantity of thermometers were in use. They began with 20,000 thermometers. After a while the Grand Duke of Weimar established a similar institute at Zurich, where a great number of glass-blowers lived in a little village, and there they had about 30,000 medical thermometers every year to test; every thermometer was stamped and numbered, and a certificate was given for it. The number tested in Berlin was not diminished, but rather augmented, in consequence. They were at present testing a large number of chemical thermometers, which were used for higher temperatures, and in which, by bringing compressed nitrogen into the upper part of the thermometer, it was possible to get to nearly 500deg., the mercury by the compression of the nitrogen being enabled to be used in the thermometer until the glass part of the thermometer began to soften and to melt. In the practical division they had also control of the standards of resistance and current, voltmeters, and galvanometers, which were in practical use. They were not very perfect yet, because they all depended on the demagnetisation of iron; but they had found means of getting sufficiently accurate indications for practical use with those instruments. They were now working at new experiments as to the use of indicators on steam engines. A great deal of attention, too, had been given to photometry for the gas and electric lighting companies. There were many different opinions as to the best unit of light, and they had not used the normal English candle, which was not very accurate or reliable, nor the French carcel, They had tried to get a chemically-covered substance with which they could get to a certain limit, and obtain a uniform amount of light at all points; but it was found that the air in which the candle burnt, and the meteorological conditions had a great influence on the amount of light. In some kinds of weather the light was very irregular, and varied as much as 5 per cent. They had made their comparisons always with electric glow-lamps. It came out that the current must be measured to the tenth part if they wanted to be certain that the light emitted by the wire was certain to one-thousandth. They were still pursuing that investigation. As for the method of M. Violle in Paris, they found it too difficult to melt down a great quantity of platinum, so that the platinum surface was quite pure. The slightest degree of impurity, even a little dust spread over the surface of the molten platinum, altered the whole determination; and then the definition of that unit of light depended upon observations which must be made at the moment when the platinum became solidified and it was extremely difficult to make a definite measurement—there was not time. Some good results, however, had been achieved by this method, in a way proposed by Dr. Werner Siemens, using thin strips of platinum, which were melted by electric current; indeed, it really seemed that used in that way it was a better standard of light than any hitherto employed. Switzerland and Austria were now paying more attention to the importance of a system of schools for mechanical and engineering purposes, and he was pleased to hear that similar schools were also spreading in England In the scientific part of their institution in Berlin they had proceeded very carefully with researches on the value of electrical standards. They were obliged at first for technical purposes to go on as swiftly as possible and they had made proposals to the German Government which were very similar to those made by the British Association to the British Government, differing only on some special points. Then they had begun a great work which should prove of fundamental importance in thermo-dynamics. In making those investigations it became quite clear that many of the calculations of Regnault were not very accurate; a great many errors in calculation had been found already. To carry out this investigation they had subdivided the work as carefully as possible, so that many determinations might proceed simultaneously. This was a great and an extensive work, which could, of course, only proceed very slowly. Years must pass before they could reach perfection.

* Lord KELVIN: I am sure it is with very great pleasure that the Section has listened to Prof. von Helmholtz. The subject opened by Prof. Lodge in his presidential address to Section A of the British Association last year is really one of national importance. I think, after what we have heard from Dr. von Helmholtz, we need have no hesitation whatever in feeling we have ample ground to go upon to prove the value of such an institution as the Physikalische Reichsanstalt of Berlin. As Prof. Lodge has shown, in a faint and imperfect manner we have done here and done there and in other places some slight things towards the great object which has been realised in Germany. What greatly struck me during the speech to which we have just listened were Prof. von Helmholtz's remarks with regard to thermometers: 20,000 in Berlin, 30,000 in the Thermometric Institute of Weimar! This is really a matter of life and death; it is a matter of life and death to be able to distinguish between a temperature of 98deg. and 98½deg. Fifty years ago with the very best and most expensive opticians, who combined with optical work the sale of thermometers at 15s. or £1, errors of from 1° F. to 1½° F. were found. Our thermometer testing at Kew corrected that state of things about forty years ago. In it the testing of thermometers is practically carried to a very close degree of accuracy; and thermometers so tested can now be purchased at moderate prices from ordinary opticians in this country. I do not know whether it is from Germany that our clinical thermometers are now obtained; but medical men have discovered that the practical use of clinical thermometers is of extreme value. We want to be told what is done in Germany in order that we may be led to increase vastly our resources in this direction. It is not a matter of national jealousy; but it may be properly a matter of national emulation. It is a noble object to prompt the artisan of England to put in as good work, and to have as good scientific direction for his work, as his brethren in Germany. After what we have heard of what the Duke of Weimar is doing for promoting the usefulness of the work of the large number of glass-blowing artisans in his principality, we must feel that it would be well for the Government of this great United Kingdom to do all it possibly can to render the work of the artisans of England, Ireland and Scotland useful to this country. The grand success of the Physikalische Reichsanstalt may be judged to some extent here by the record put before us by Prof. von Helmholtz. Such a proved success may be followed by a country like England with very great profit indeed. One thing Prof. von Helmholtz did not mention was the discovery in the Anstalt of a metal whose temperature coefficient in respect of electrical resistance is practically nil; that is to say, a metal whose electrical resistance does not change with temperature. This is just the thing that we have been wanting for twenty or thirty years. It is of the greatest importance in scientific experiments, and also in connection with the measuring instruments of practical electric lighting, to have a metal whose electrical resistance does not vary with temperature; and after what has been done, what is now wanted is to find a metal of good quality and substance whose resistance shall diminish as temperature is increased. We want something to produce the opposite effect to that with which we are familiar. The resistance of carbon diminishes as temperature increases; but its behaviour is not very constant. Until within the last year or so nothing different was known of metals from the fact that elevation of temperature had the effect of increasing resistance. The Physikalische Anstalt had not been in existence two years before this valuable metal was discovered.

Prof. VON HELMHOLTZ: The discovery of a metal whose resistance diminished with temperature was made by an American engineer.

Prof. AYRTON: By an Englishman—Weston.

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Lord KELVIN: That serves but to intensify the position I wished to take, whether the discovery was made by an Anglo-American, an American Englishman, or an Englishman in America It is not gratifying to national pride to know that these discoveries were not made in this country.

The PRESIDENT: We ought to hear the opinions of as many of those present as possible. Dr. Gould is connected, to some extent, with the subject, and we should be pleased to hear him.

Dr. GOULD: I have very little to say on the subject; but as I have the honour to be a member of the International Committee, I would use this opportunity to mention one point. Mr. Glazebrook spoke of what the French have done in thermometry. I would remind him that the work to which he alluded is being carried out by an International Committee, on which England is represented.

Prof. RÜCKER: I understand that it is desirable that those who speak should be as brief as possible, and I will only refer to two points of which I have practical knowledge. In the first place, with regard to thermometry, as a member of the Kew Committee I may say that a short time ago we wished that our mercurial standards should be compared as closely as possible with the hydrogen thermometer, and it was not altogether satisfactory that we had to send our instruments across the channel to Paris in order that the comparison might be made. As a matter of fact—and this shows the risks to which they are liable in transmission—one of the thermometers was broken. It is quite evident that we ought to have in England some place where measurements of that kind can be made. Of course, the Kew Committee would be willing to compare gas and mercurial thermometers; but two things are wanted—money and room. Then, again, with regard to another matter to which reference has been made—photometry. As those present well know, we have for years been giving great attention to determining the unit of light, and we owe much, in fact nearly everything, to one of the officers of this Association, Mr. Vernon Harcourt. A good instance of the way in which matters of this kind are dealt with in England is the fact that some twelve years ago a Board of Trade committee investigated and reported strongly in favour of Vernon Harcourt's pentane unit: nothing has yet been done, and the question is now remitted to another Board of Trade committee of which I have the honour to be a member, yet I cannot but feel that the enquiry might be best worked out by a permanent staff attached to a Government institution. Those who know—as most here do—the engagements with which most of our time is occupied well know how difficult it is, for instance, for a man like Mr. Vernon Harcourt to come up to London to carry out experimental researches. As a matter of fact, he had to give up half his Long Vacation to do it, and it has been extremely difficult for the rest of us to fit in with his time. Naturally the work is not done so quickly, or with that thoroughness, which would be the case if it were in the hands of a Government institution. As far, therefore, as everything connected with the standards is concerned I think there is very little doubt that it would be extremely advantageous if a national institution could be started, largely in connection with the Royal Society, for the care and comparison of standards. There is one other point. Although it is quite right that such an institution should carry out such researches as its directors might think desirable for the progress of science, nevertheless I do hope nothing will be done in this direction to divert the meagre funds at our disposal for the encouragement of individual research. There are certainly cases where individuals carry out important tasks which a corporate body refuses to undertake. I hope, therefore, the Government Grant Fund for research will be allowed to remain as at present, and that the Royal Society will still be able to encourage investigators as much as they now do. I should be extremely sorry to see research and teaching in any way divorced. Both for the sake of the students and of the professors it would be a great pity if scientific men became divided into two groups, those who investigate and those who teach. The experience of Germany, at all events up to the present, shows that there is no serious risk of that disaster. In that country we know that in spite of the success of the great institution which Professor von Helmholtz has described, the universities and colleges do a great amount of original work. While, therefore, we are careful to provide for original research, we must also be careful to keep together research and teaching.

Captain NOBLE: I take it that we are all agreed that the National Physical Laboratory is necessary. Dr. Lodge has laid the whole subject before us; and I fancy none of us, either laymen or professors, doubt the desirability of establishing a Physical Laboratory, and I merely rise to suggest that a resolution be passed by this Section to be forwarded to Government in order that some arrangements may be made for utilising that department of education known as the Science and Art Department at Kensington. There is an impression that that department is not very active with its practical work, that the value of its work is not quite so high as it might possibly be. I may be wrong, but there is that impression; that there is a little time now and then which might be devoted to this particular purpose. That is to say, that some of those gentlemen might be employed in examining the questions which it is so necessary should be examined by a central body; and I would suggest that a resolution to that effect, if it be in order, be prepared and submitted to the meeting, and forwarded to the Government. We might rely upon the support of Lord Kelvin and the learned President of the Association, Sir Archibald Geikie.

The PRESIDENT: It is not usual for the Section to pass any resolution of this kind. We have appointed a Committee, and if the Committee reports it will go its natural course through the Council, and the Government be approached in that way. A resolution would be quite out of order here.

Prof. G. F. FITZGERALD: I would like to say a word as to what has been said with regard to our all being quite agreed that a National Laboratory is desirable. We ought in the first instance to consider carefully whether we can develop our present resources. There are certain institutions which ought to devote themselves to this work a great deal more than they do at present, and if anything is to be done I think it is that a Commission should be appointed to inquire how it is that these present institutions do not do the work they are supposed to do, instead of proposing to start a completely new institution. I only bring this forward because I think it desirable that views of that kind should be expressed. In order to get money from the House of Commons it is necessary to prove that some definite advantage will accrue to some definite class in the community which will be an important class of the community. For instance, in the case of Berlin, as I understand it, it was necessary to provide something required by the Army and Navy. If it can be proved that something like the Physikalische Anstalt is required for the Army and Navy there will not be the least difficulty in persuading the British Government that it is necessary to provide it. But I have not heard that it is required for the Army and Navy or for any serious class. The English people and the House of Commons are not sufficiently educated to understand that the mere advance of scientific work is of value to the community. Until we have persuaded them of that I do do not think it will be worth while for the British Association to ask for anything very definite, because the House of Commons first requires a great deal of education in the necessity for general scientific advance to prove to them that general scientific advance is of importance to the community, and until they learn that it is of very little use for the British Association to press this particular request. As I have said, there are certain institutions which ought to do this at present. The business of a university is research; that is its first business; the second is to teach. They would have money enough if they would not spend more than the proper amount of their funds upon the students and the cripples who go there. The first thing that the House of Commons would do would be to find out whether the money which ought at present to be spent in such work as has been alluded to, is really spent in that way. Something like £600,000 a year is spent in two universities in England, and plenty of money might be got out of that to carry out scientific research, literary research, or anything else, if it were properly spent. But an enormous amount of money is spent there in teaching cripples to run. The first thing which should be done is to petition Parliament to inquire whether the universities spend their money in the way it should be spent, and to try to get that money spent in increasing the scientific and literary work of the country. The only pressing thing standing out at present that requires to be encouraged is this standardising work that is being done in the laboratory at Cambridge. There is now a Board of Trade Committee starting on that work; all that is required is that they should develop their work in that direction, and that money should be spent on that, when the only outstanding work desirable for the good of the country would be being done by a central institution. It is not at all obvious that it is desirable to amalgamate the Board of Trade work with the work done at Kew and at Greenwich; on the contrary, there are a great many advantages in having a number of different institutions carrying on different kinds of work, instead of one enormous institution under an autocratic head, carrying on the whole thing. It is very desirable in some ways that the different things should be kept separate. Another thing could be learnt from Berlin. Who was it started this institution? Werner Siemens—a private individual. Where are all the private individuals with hundreds of thousands, millions, of money, who take example by the Grand Dukes in Germany? Where are the Grand Dukes in this country? I would only reiterate that I do not think the time has come yet for pressing upon the Government to start anything of the kind. The matter requires a great deal more, a great many years more, careful consideration before it is clearly shown that a Physikalische Anstalt, such as that at Berlin, which has been supplemented by others in another part of Germany, is desirable in this country. It would be very much better if universities, with the immense funds at their disposal, or with additional funds given them, to dispose of, if that is necessary, would undertake the work of research required by the country, because it is undoubtedly their business.

Sir GEORGE STOKES: I do not altogether agree with Prof. Fitzgerald that the first work of universities is research, and that teaching is merely something subordinate. My notion is that the first work of a university is to teach. In order that this teaching should be well done it ought to go hand in hand with research; of that there is no doubt at all. But what sort of research? The researches that Prof. Lodge contemplated as what in his opinion ought to be undertaken by a national institution, are not precisely of the kind which would be suited to bringing out the ardour of young students. They want rather to have their enthusiasm excited by something which holds out a prospect of a new discovery, some new advance in knowledge. Of course, a long and laborious series of quantitative measurements are important as conducing to our stock of knowledge; but where the researches are such as go on year after year, they are not of a kind to bring out the enthusiasm of young men. Therefore I think the universities are not the proper places for carrying out those long-continued laborious researches of the kind which Prof. Lodge contemplated. I will just say one word more with regard to what Prof. Fitzgerald said as to private individuals coming forward and furnishing from their own resources—I mean, of course, wealthy individuals—means for carrying on such researches. Now, there again, I think you could hardly expect private individuals to form institutions of that non-ecclesiastic character, if I may call it so, which Prof. Lodge contemplated. But I cannot sit down without reminding Prof. Fitzgerald that the institution at Cambridge, which has already been mentioned in such terms of commendation—I mean the Cavendish Laboratory—was founded by the private liberality of our late Chancellor.

Lord KELVIN: The real primary duty of universities is to teach. Research naturally falls in with teaching, happily for professors and others whose duty it is to teach. But Prof. Fitzgerald seems to forget that the life of a student is three years, and his laboratory life six months. Surely

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an institution whose primary duty is to teach should make the best of the time it has with its students, and cannot get much of it for research. Certainly research ought to be continued, and must be continued, in University physical laboratories, but I think there is a great want of an institution where graver research than anything that can be done in a student's laboratory may be carried out, and where there should be a greater permanence than is permitted by the fluctuating circumstances of the workers, if not of the conductors, in the universities. Why not private individuals? If any private individual will come forward with £500,000 to endow the nation with a physical laboratory, certainly the gratitude of the world will be accorded to him. But if it is of national importance is it dignified that we should wait for a millionnaire to do it? It is a very poor argument to use to the Government—"If you wait long enough there may be a chance of some millionnaire in this country or in America doing it for us." That it would be desirable to establish such an institution is proved as much by Prof. Fitzgerald's opposing it as by any of the speeches made in favour of it.

Prof. CAREY FOSTER: This question of research and the sort of work which should be done by the National Laboratory seems to me to be a little bit confused. We have had the laboratory advocated for the sake of the benefit to be conferred on industrial operations; but I think beyond that there is a still greater reason in what I may call the advancement of pure scientific knowledge. The idea that such an institution, if established, would be the home of physical research for this country seems to be quite apart from the idea which Prof. Lodge has put before us. It would not supersede research and investigations of private individuals, and university professors and other officials; but it would rather support and assist them. The work which, as I understand, it is wished to take up, is determinations of the utmost accuracy of numerical constants, work which could scarcely be done by individuals, in consequence not only of the expense involved in it, but the enormous time required, the continuity of work and observation necessary for great accuracy. Very often what seems to be the simplest possible operation is almost inconceivably difficult without quite special knowledge of the subject. I might refer to one of Prof. Fitzgerald's propositions with regard to private munificence. Sir George Stokes has already reminded us that the one chief place where work of the kind is carried on, the Cavendish Laboratory, is due to private munificence, and I may add that the only place in this country which approaches the same end, the Kew Observatory, is also privately endowed.

Prof. AYRTON: I am afraid my ideas are not very clear on the subject. As to the function of a university, to a great extent I agree with what Prof. Fitzgerald has said. I also agree with what Sir George Stokes and Lord Kelvin have said. I think the proper function of a university is a combination of the two—is to teach by or through research; and that is why I think the teaching given by a professor at a university should differ from the teaching given by a schoolmaster. In one case the schoolmaster is teaching what is already known, but what the student at a university should be taught is the way to find out what is not known. I can quite see the sort of experiments Prof. Lodge has referred to; the finding of the fifth or sixth decimal cannot be carried out without great difficulty at the ordinary university. On the other hand, it is most improbable that the British Government would give any money whatever for the purpose of bringing out the sixth decimal; they have absolutely no interest in such matters. There is need for far greater facility for standardising; that is a far different thing altogether. A large portion of the work carried out by Reichanstalt is the certifying of Clark cells, electrical standards, and other similar work. Now we already have not merely a committee who advise the Board of Trade, but there actually is a Government Standardising Laboratory in Parliament-street at the present moment, and if 20,000 or 30,000 galvanometers were brought there no doubt it would be enlarged to do that large amount of work. I fancy if the English population were to send 20,000 or 30,000 thermometers a year to be standardised in the same way the facilities at Kew would be increased; there would be no difficulty whatever in getting the Government to take up standardising. There had been no great difficulty in getting the Board of Trade to start that Electrical Standardising Laboratory. But when that proposal was first brought forward at the Institution of Electrical Engineers, I ventured to say what Prof. Fitzgerald has said far more eloquently to-day. I may mention that the proposal brought forward was that there should be a Government Electrical Standardising Laboratory for a different kind of work, one for standardising instruments and the other for the carrying out of electrical research; and I pointed out that the latter was really one of the functions of a university. No doubt there is great need of facilities for standardising instruments, and that we have already obtained, and it will undoubtedly be very much enlarged if there is any need. There remains this other need of getting out the fourth or fifth place. I do not see at all why that is to be carried out. It seems to me, as has already been said, that it is quite impossible to get the English Government to give money for secular researches, and I fear for the present all we can hope to do is to largely increase our facilities for standardising commercial instruments, leaving to universities and to private people both researches for the advancement of knowledge and also for getting greater accuracy in our physical constants. One thing has not been suggested which I do think requires consideration; that is, the too much teaching which is demanded of professors. Say, for instance, the reader of the Paper, Dr. Lodge, who, as everyone knows, has done most magnificent work in a particular line of research in connection with electro-magnetic radiation; but quite recently the authorities of the University at Liverpool have decided that Dr. Lodge, with assistance, ought to teach electrical engineering. I do not mean to say that Dr. Lodge is not able to teach that, but he is able to do very much better work, something else that others who can teach electrical engineering cannot do. The carrying out of Prof. Lodge's suggestion of starting a National Laboratory would, I fear, bring about that which I deplore so much—that professors would be told it would be their duty to teach all sorts of things, and not pursue research. What we ought to aim at is to give greater freedom to professors and others in the matter of original work.

* Prof. LODGE: I hope this matter will not be undertaken by an individual; I think it is really an Imperial matter. There is so much for private munificence to do in local matters, starting colleges, and endowing local institutions; but this is Imperial work. Much has been said of the difficulty of approaching Government. It cannot be said that the First Lord of the Treasury is at all averse to scientific ideas; and no doubt there are other members of the late, or present, Government, whichever it is, who would be in the same position. Our position is not to see difficulties in the ignorance of the House of Commons, but to try and teach them the proper thing; we should not feel these difficulties too strongly. With regard to teaching, Prof. Rücker said teaching should not be divorced from research. But let him just remember how many an English professor gets taught? He goes to Germany and in some such place as the Reichanstalt under von Helmholtz becomes for a time one of his 70 assistants there. Is not that teaching, and teaching of the right sort?

The PRESIDENT: Before concluding the discussion, I am rather anxious that the principal points which that discussion seems to me to have brought out should not be lost sight of. Some of the remarks that have been made, especially with regard to the function of the university, seem to me a little beside the question, to have nothing to do with the question at hand, and I am afraid they may have rather obscured the main points at issue. There are two or three points clearly shown by the statement of Prof. von Helmholtz, and which it would be well for the members of the Section to remember. It is generally acknowledged, even by those who are opposed to the establishment of a laboratory, that a place to standardise instruments is necessary. Now I hold, and I think it has been shown that no confidence can be reposed in a place where only the standardising of instruments is carried on, and where no research of the highest kind is pursued at the same time. That is the most important matter brought out by Prof. von Helmholtz. An instance has come to my notice. It has been said how important the Reichanstalt has been in thermometry in finding out the right kind of glass. Kew has been testing thermometers with a view of ascertaining whether it is possible to get glass here which will do equally well. I have thermometers in my pocket which Joule made in 1840. That glass is as good as any that can be made now. The art of making glass has been lost. The glass made now is not of the same nature as that made in this country fifty years ago. I believe if we could get back to the glass used at that time we should have thermometers equally as good as those. If such work had been carried on at Kew, together with the testing of thermometers to a greater extent, our instrument makers would be in the position of making thermometers of a very high order. There is this other point clear also from the remarks made, the enormous importance of research work of this kind to the artisan, to the instrument maker. That has, I think, been clearly shown, and I will not take up the time of the Section in proving the point. It has been suggested that Prof. Lodge has asked for a new departure. It seems to me, however, that all that is asked for is that physics should have what astronomy, pure astronomy, has had for a very long time. It is all very well to say that Greenwich is necessary to navigation. If you were to take away everything at Greenwich that has no direct bearing on navigation you would have very little left. The country is proud of Greenwich, but it does research work chiefly, and the actual work necessary for the Navy is really a small matter. Therefore, what is now sought is not a new departure, but really an extension to another branch of science of that which has grown to be necessary in the oldest science of all—astronomy. I am sure that whatever may come of this discussion it has cleared up our ideas on the subject, and I ask you to thank Prof. Lodge very heartily for again opening up this subject, and to accord a special vote of thanks to Prof. von Helmholtz for the information he has given us regarding the Physikalische Reichanstalt.

CORRESPONDENCE.

BRITISH ASSOCIATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 12th August you state that the reading of two Papers on Transformers at the British Association was accompanied with a considerable drop in the attendance; but you do not mention that this drop was really caused by the absence of "feeders."

To retain their presence during the lunch hour is practically impossible. And without feeders, as every electrician knows, a drop is inevitable.

Further, so many Papers were put down to be read that the alternation from subject to subject was necessarily very rapid. Now, as was shown in one of the two communications in question, the greater the frequency the greater the drop. In fact, towards the end of the meeting, the rate of alternation became so high that in Papers rather than in people was the drop most apparent.—I am, Sir, &c.,

Switzerland, August 29th. W. E. AYRTON.

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THE DIMENSIONS OF PHYSICAL QUANTITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The dimensional expressions [L], [M], [T], &c., are defined in two ways, viz., as concrete units, and as change ratios; and the point at issue is as to the merits of the two systems founded on these two methods of definition.

When, then, Prof. Rücker states that the equation [L] = 2 is "false by definition of the symbol [L]," he affords us an unusually glaring instance of the fallacy *petetio principii*.

Of course, if [L] is a length, [L] = 2 is absurd; if [L] is a change-ratio, to say that [L] = 2 is merely a concise way of saying that we choose to halve our unit of length, and is neither absurd nor false by Fourier's rule, which, indeed, has nothing to do with it.

It is kind of Prof. Rücker to explain to me the origin of my difficulties; but on this subject I have none. I avoid them all by adopting the change-ratio definition of the dimensional expressions.—Yours, &c., W. M. M.

LEGAL INTELLIGENCE.

At a sitting of the Consistory Court of London, held on Monday last in St. Paul's Cathedral, before Dr. Tristram, Q.C., Chancellor of the Diocese of London, an application was made for a faculty to authorise the construction by the City of London Electric Lighting Company of a transforming chamber in the churchyard of St. Benet Fink, Royal Exchange-avenue. Mr. Arnold Statham appeared in support of the application. The churchyard was vested in the Corporation of London by the Act 5 and 6 Vic., cap 101. The rector and churchwardens had consented to the transforming chamber being constructed in it subject to the leave of this Court having been first obtained.—The Chancellor reserved judgment.

This was also the result of an application for a faculty to authorise the construction, by the City of London Electric Lighting Company, of a transforming chamber in the churchyard of St. Nicholas Cole-Abbey.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—We would remind our readers that 11 a.m. Thursday next, the 8th inst., is the latest time for depositing with the Chairman of the Gas Committee of Leicester tenders for lighting the Corporation area of supply. Particulars appear in our advertisement columns.

——— The Urban Sanitary Authority of Portsmouth invite tenders for the erection of an electric lighting station in the Gunwharf-road, Portsmouth. Tenders must be delivered to the town clerk by 6 p.m. on the 26th inst.

——— The Corporation of Bradford require tenders for the supply and fixing of new roofs, floors, and other works. Particulars of Mr. W. T. McGowen, town clerk, Town Hall, Bradford. Tenders to town clerk by the 7th inst.

PLANT FOR SALE.—Our advertisement columns contain a notification of the sale by private treaty of the lease of the premises lately occupied by Mr. J. Collins at Hove, together with the modern stock of electrical plant. Full particulars may be obtained of Messrs. Ward and Wilding, chartered accountants, Bloomsbury Mansions, Hart-street, London, and 8, North-street, Brighton; or of Messrs. Bullock and Sadler, 33, Queen's-road, Brighton.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—This Company announce that on and after the 1st instant a new station will be opened for the reception and delivery of transatlantic telegrams at 39, Mark-lane, E.C., and that this station will be opened day and night, Sundays included. In future the Company's station at 34, Throgmorton-street, E.C., will be open from 9 a.m. to 8 p.m. from Monday to Friday, and from 9 a.m. to 6 p.m. on Saturday, but will be closed on Sunday.

BANKRUPTCY.—A receiving order was issued on the 27th ult. against the estate of Messrs. Cox, Robinson, and Co., carrying on business as electrical engineers at 8, Strand-street, Liverpool.

——— The following are the principal creditors against the estate of James Collins, lately carrying on business as an electrical engineer at 80, Church-road, Hove:—

	£	s.	d.
(?) Electric Light Company, London	50	7	5
Emanuel and Son, London	38	14	0
Gent and Co., Leicester	15	7	8
Gulcher (New) Electric Light and Power Company (Limited), Battersea	100	0	0
India-rubber, Gutta-percha and Telegraph Works Company (Limited), London	20	9	5
London Electric Wire Company (Limited), London	12	10	11
Robey and Co. (Limited), Lincoln	89	0	0
Verity and Sons, London	131	8	5
Woodhouse and Rawson United (Limited), London	89	3	10

The total liabilities are set down at £2,158, and the assets, after deducting preferential claims, at £949.

MESSRS. DRAKE AND GORHAM.—We have received a copy of this firm's latest illustrated catalogue, which contains full particulars with regard to their well-known specialities such as ring contact switches, excess indicators, battery testers, Cardew earthing devices and voltmeters, &c., &c.

CLUB LIGHTING.—The Conservative Club, St. James'-street, is undergoing redecoration, and it has been decided to introduce the electric light. It is estimated that about 400 lights will be required, and the work will be done under the superintendence of Mr. A. A. Campbell Swinton.

DISSOLUTION OF PARTNERSHIP.—The partnership is dissolved between Messrs. Simpson and Hill, carrying on business as manufacturers of electrical, optical, and scientific apparatus at 2, Aldersgate-buildings, E.C. Debts will be paid by Henry Hill.

COMPANIES' MEETINGS.

The City of London Electric Lighting Company (Limited).

The second annual general meeting of the City of London Electric Lighting Company (Limited) was held yesterday at Winchester House, Old Broad-street, Sir David L. Salomons, Bart., presiding.

The SECRETARY (Mr. J. Cecil Bull) read the notice convening the meeting. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: On the last occasion that I had the honour to appear before you with a considerable amount of difficulty we waylaid one shareholder in the passage and got him for our audience. I am pleased to see to-day that you are so many in this room. It shows, at any rate, that if, before, you had every confidence in your Board carrying out your work, now your interest has wakened up, and I trust that your confidence is not less in consequence. I propose now, before moving the adoption of this report, to place before you all that has taken place since the last meeting. On that occasion I gave you a history of the formation of the Company up to that time; I will now continue it up to the present day. The applications for shares then amounted to £300,000, which we considered very good; £100,000 remained to be applied for. This, I am glad to say, is now not only all applied for, but will be employed for your work in a very short space of time. The whole of the ordinary share capital has, therefore, been taken up, and the money will have been spent probably in another month or six weeks. It is, therefore, the intention of your Board to issue some preference stock. It is intended at present, and I have no doubt the intention will be carried out, to issue half the preference stock—£200,000—at 6 per cent.; and to give the shareholders the first chance of obtaining it. You will find, I think, that this 6 per cent. is very well secured, and may be regarded as a first-class property when in your hands. I think myself, and I believe the Board will in a great measure agree with me, that before very long—not to be too hopeful, say within twelve months—that we shall be in a position to pay a dividend to the ordinary shareholders. Matters have now begun to mend. The first difficulties that had to be encountered have been met, and very satisfactorily met. The stations are working now, not at a loss, but at a small profit, which will grow as the machinery comes into work. At present we are not working a full load. As that is put on the money will come in, and every penny will give a profit, for the standing charges will not increase in proportion. It is merely the coal bill which goes up, and that is comparatively small after the staff has been paid and the office expenses and various other matters have been met. We have at the present time a site and buildings and other works which must exist, and all these bring in no return. That is a necessity of all companies and undertakings of this nature. All the money that we now expend will be fruitful in the future. There are one or two points in the report that I would like to call your attention to. On page 3 there are the words: "From calculations based on the lamps already connected to the Company's mains, it appears that the consumption of current per lamp installed in city offices, shops, &c., will be much greater than was anticipated." It was pointed out to me by a gentleman that, perhaps, that might be taken to mean that consumers of electric energy in the City were paying more than in other districts, or in some way were at a disadvantage. But that is not so. In the West End, where there are drawing rooms, and people give parties occasionally and are away for the greater part of the year, and in shops, where they are only alight for a very short time, you will find that the number of lamps installed is perhaps four times the number in general use. The average earnings of a lamp would in that case be only one-fourth of its capacity. In the City matters are different. Of the lamps installed, probably almost all are in use when the weather is dark, and consequently the return per lamp is greater. I should also mention another point. That is the matter of not stinting money in putting up your fittings. It is a loss in the long run to do so. It is much better to have your work thoroughly well done, so that no trouble will ensue with the light. Nothing has brought a bad name upon electric lighting quicker in many places than the fact that the fittings have been bad. With water, gas, and drainage every precaution is taken, but with electric lighting the general rule is that the man who will give the lowest tender is given the job, and the result, in most cases, is not satisfactory. I have no doubt you have been round the City and seen the beautiful illumination now visible at night and you will see it better by-and-bye, when the days grow short. One thing that must strike you is that all that is in sight is thoroughly well

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done and the work out of sight is just as good. Go even to the works and you will find there, though the place is now in great confusion in consequence of the presence of builders and the erection of machinery, that what has been done and is doing is conducted in a thorough manner. After now nearly every pound spent will bring a return. Everything which the Company has done has been done thoroughly, not in "gingerbread" style, and it has been the first wish of the Board to give satisfaction to the City authorities and the public. This was not at first appreciated, but by this time it must have become evident to all. The Directors have spared themselves no trouble, nor have they considered their private convenience in carrying out the affairs of the Company. The Board goes into every detail before money is spent, and inquires into the doings of sister companies, in order to gain experience from the success and failure of those gone before them. One circumstance we deeply regret, it is the absence of Mr. Charteris to-day. He has been long ill, but we hope that the time is not far off when he will join us again and assist us in our work. I am pleased to say that all calls are in with the exception of £62. Before sitting down I will give you a few details of our work during this year for your information and for those who are watching our progress. You must remember that when our buildings and their contents are finished, the standing charges will practically be stationary. The variable quantity will be the coal bill, so that if we are able to show a fair result during the next two years success is assured, provided our customers continue to increase as in the past. The lighting of the City is exceptional, as the curves before you show; in fact, they are contrary to the experience of all other companies. We shall require a favourable winter from one point of view, *i.e.*, one abounding in fogs and dark days, in order to learn what the City population require of us. The Board have no desire to be extortionate, and when the shareholders obtain a fair return on the capital they risk, and after due provision for sinking fund, reserve fund, and maintenance, they hope to reduce the price of the current. I know that the Board, with their officers and *employés*, are doing their best to meet the confidence reposed in them by you and the public. They simply ask a little patience and indulgence until the works are completed at the stations and sub-stations. Your Board have not lost sight of a probable demand for energy for motive power which is certain to arise for lifts, running machinery, cranes, advertising purposes, &c., and they have laid down a large reserve of spare ways, to avoid the expense and inconvenience which would arise by opening the streets a second time. It may be mentioned that it is proposed to work all cranes, pumps and other machinery at the stations by electro-motive power. It is expected that many markets, railway stations, and other public places will obtain current from us for arc lighting. The rules laid down by the Board of Trade practically rendered this field of lighting impossible for a public lighting Company. The Board, therefore, waited as a deputation upon the Board of Trade, and they were very kindly received by Sir Henry Calcraft and Sir Courtenay Boyle. The result was that our request for a modification of the rules were acceded to, if certain precautions were taken. The details of these precautions have yet to be settled. The most pleasing circumstance connected with the interview is the disposition shown by that Government Department to assist the public in obtaining the prince of modern lights. Any points connected with the report or the accounts I shall be happy to explain, also to reply to any questions you may desire to ask at the close of the proceedings. You will observe that the cost of working the stations is "turning the corner." It is our intention to have the curves before you kept up regularly and photographed yearly, to be sent round with the reports. Much information will be given to you this way, and to scientific men, who are working on the same subject, these results will be invaluable. It is not our desire to have any secrets, but to give you and the world the fullest information. This course will assist the cause of electric lighting more than any other. By the spring it is expected that our stations will be able to supply 78,000 8 c.p. incandescent lamps, in addition to the 700 arc lamps which can be run now. These figures represent totals including reserve. Considering the inclemency of the past winter, and the short time which has elapsed since the starting of this Company, we claim that the amount of work done is beyond precedence, 'beating the record,' as sporting people say. Our present gross earnings exceed £20,000 a year, and this will increase as we are able to meet the demand for current. So far the demand has always exceeded the supply. Although we are distributing energy at this moment under many disadvantages, the total loss of electric energy from station terminals to consumers' terminals does not exceed 26½ per cent. When our dynamos and transformers get their full load—now they only work at half load—a very good result may be expected, showing that our system of distribution is good. All the machinery which has been erected is of good workmanship and sound, and it is satisfactory to learn that the machines now in course of construction will have a capacity 10 per cent. higher than that contracted for continuous work. This is ascertained from tests on similar machines recently completed. These machines were intended for 6,000 8 c.p. lamps. Fogs will no doubt test the efficiency of our installations very severely, yet we have every reason to believe that we shall meet the difficulties with perhaps a little trouble upon the first or second occasion. Probably observations made from elevated points will assist in ascertaining the approach of a fog. The Docks Committee has kindly promised telegraphic communication from the docks when fogs come from that direction. In any event every means will be tried for obtaining notice of a fog coming on by telephonic communication and other means from points around London. To give you a notion of the progress of the street work I may mention that at times as many as 30 miles of tubing were placed underground in a week, and the average for the year has been about 10 miles of way per week. The contracts with the City for arc lighting in main thoroughfares required the laying of trenches in 47,072 yards of streets. On June 30th 43,134 yards were laid and now 45,410 yards, leaving to complete 1,662, which will be finished during the next three or four weeks. Of the work in the lesser streets not compulsory on June 30th, trenches were laid 46,378 yards, or about 26⅓ miles, now 49,412 yards. There has been laid to this date 303 miles of ways. The length of cables drawn in to date is 63¼ miles of high tension, and 22 miles of low tension. On June 30th there were in the streets 184 arc lamps, now there are 334. By the middle of this month all arc lamps under the City contracts will be running, excepting a few delayed for special reasons, such as building operations, reconstruction of refuges, &c., our last day really being November 5th, so that we are unlike most contractors in being ready before our time. On June 30th there were 11,800 8-c.p. glow lamps on 6,735 yards of main, giving a lamp density of two lamps per yard of main. If this density were to hold good throughout the area of the street work now ready to receive, mains would give 190,000. In Lombard-street the density is six lamps per yard, and Cornhill is very nearly the same. Our two stations, since August 1st, have been supplying current continuously day and night. In placing before you so many facts and details my wish has been to render you a full account of the work in which you are embarking your capital, and to show you that those in whom you have placed so much confidence are not going to sleep or to allow their energies to rust. I have now to move:—

"*That the Directors' report and the statement of the accounts to June 30, 1892, be and the same are hereby received and adopted.*"

Mr. PURCELL seconded the motion, which was carried unanimously.

Mr. PURCELL moved that Messrs. W. H. Pannell and Co. be re-elected as auditors, with a remuneration of 100 guineas.

Mr. KELMAN seconded the motion, which was unanimously adopted.

Mr. CLARK, in moving a vote of thanks to the Chairman and Board of Directors, took occasion to express his sense of the admirable manner in which they had performed their difficult duties, and stated that though his ten years' connection with the Brush Company had not been financially successful, he had every confidence in the future of electric lighting.

Mr. E. K. SMART seconded the vote of thanks, which was accorded unanimously.

The CHAIRMAN having replied, the meeting ended.

NEW COMPANIES, STATUTORY RETURNS, &c

KENNEDY STORAGE BATTERY COMPANY (LIMITED).—This Company was registered on August 24th, with a capital of £100,000, in £1 shares, to enter into and carry into effect an agreement between Patrick Kennedy and Charles J. Diss and the Company to acquire certain letters patent, inventions, secret processes, &c., relating to storage batteries, and to carry on the business of electricians, electrical contractors, electrical and mechanical engineers, suppliers of electricity for the purposes of light, heat, sound, motive power, or otherwise, and manufacturers of and dealers in all machinery, apparatus, plant, materials, and things required for, or capable of being used in connection with the generation, distribution, supply, accumulation, or employment of electricity. The subscribers are:—W. J. Sutherland, Seaford, Sussex; J. Dunham-Massey, 55, Old Broad-street, E.C.; G. C. A. Kohler, 17, Fenchurch-street, E.C.; H. J. Alfred, 20, Moorgate street, E.C.; G. M. Gordon, 34, Colby-road, S.E.; W. Simpson, Wivenhoe, Wood Green, N.; L. L. Simpson, 26, Dover-street, W. Office: Broad Street House, Old Broad-street, E.C.

In connection with the above Company the following are the main facts of the agreement to be entered into:—Made between Patrick Kennedy, of 105, Johnson-street, Brooklyn, in the State of New York, U.S.A., and Charles J. Diss, of 334, Pearl-street, Brooklyn (called the "vendors"), of the one part, and the Company of the other part. The vendors are the owners of patents Nos. 16,934 and 16,938 of 1891, and No. 9,014 of 1892 (Provisional Specification), for "improvements in secondary or storage batteries, and the Company has been incorporated with a view to the acquisition and working of the said patents. It is therefore agreed that the vendors shall sell to the Company the said inventions and all patent rights granted or to be granted to the vendors for improvements in storage batteries, except in the United States of America. The consideration for the said sale to be £100,000, to be satisfied by the allotment to the vendors or their nominees of the whole of the present nominal capital of the Company. The vendors have agreed to pay all the preliminary expenses of the formation, registration and floating of the Company, down to and including the first allotment of shares, and have also agreed to pay to the Company the sum of £2,000 for use as working capital.

READING ELECTRIC LIGHT COMPANY (LIMITED).—The statutory return of this Company, made up to June 2nd, has been filed. Out of a nominal capital of £75,000, in £5 shares, 7 shares have been taken up, no calls made, and nothing paid. The original signatories are the only shareholders.

SIEMENS BROTHERS AND COMPANY (LIMITED).—The annual return of this Company, made up to July 1st, has been filed. The Company was registered on December 28, 1880, with a capital of £400,000 in £100 shares, to take over and carry on as from January 1, 1881, the business of telegraph engineers, electricians, and electrical contractors, carried on by Ernst W. Siemens, Charles W. Siemens, and Carl H. Siemens, under the style of "Siemens Brothers." By special resolution, passed January 8, 1883, and confirmed January 23th following, the capital was raised to £500,000 by the creation of 1,000 new shares of £100 each. At the time of making up all the shares had been taken up, £85 per share called, and all calls (£425,000) paid or considered as paid. No difference is made in the return between the amount paid and that considered as paid; but it appears by other documents that 3,993 shares were issued with £75 considered as paid on each share.

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CITY NOTES, &c.

BABCOCK AND WILCOX (LIMITED).—The Directors recommend that the following dividends be paid for the half-year ended 30th June last:—At the rate of 6 per cent. per annum on the preference shares, and at the rate of 15 per cent. per annum on the ordinary shares.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 28th were £895, as against £717 for the corresponding period of last year, being an increase of £88. The total receipts for half-year amount to £6,953, against £6,397 in the corresponding period of 1891, being an increase of £556.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Aug. 26, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,283.

CRICKET.—A match was started at Cadiz on the 20th ult. between the C. S. "Mirror" eleven and the eleven of the Eastern and Spanish National Telegraph Company, but was unfortunately brought to a close after the "Mirror" eleven had scored 60, owing to an accident to the awning injuring one of the players.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 24.		Price Wednesday, Aug. 31.		Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending Aug. 31.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS								
£1,247,720	Stock	12/6	Anglo-American	47	48	47½	48½	5 8 2	Jan., Apr., July, Oct.	..	..
£2,876,140	Stock	25/0	Do. Preferred	87½	88½	88	89	6 3 7	" "	88½	87½
£2,876,140	Stock	5/0	Do. Deferred	10½	10¾	10½	10¾	..	" "	10⅞	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	10½	11½	10½	11½	6 4 5	Mar., June, Oct., Dec.	11½	11
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	$13	Commercial Cable Capital Stock	160	165	160	165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine xd	11	12	10½	1 ⅛	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10% xd	17½	18½	17	18	5 11 1	" "	18½	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3¾	3½	3¾	4 16	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5	" "	..	..
60,710	20	3/6	Direct United States	11⅜	11⅝	11⅜	11⅝	6 0 2	Jan., Apr., July, Oct.	11⅝	11½
400,000	10	5/6	Eastern	14½	15	14⅝	15	4 6 8	" "	15	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	15½	16	15½	16	3 15 0	" "	15⅞	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	109	112	109	112	3 1 5	May and November	112	..
£900,000	100	5%	Do. 5 per Cent. Debentures 1899	106	109	106	109	4 11 9	February & August	109½	..
250,000	10	2/6	Eastern Extension	15	15½	15	15½	4 12 7	Jan., Apr., July, Oct.	15⅜	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 9	February & August	109½	108½
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103	106	103	106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103	106	103	106	3 15 16	February & August	104	..
180,227	10	3/9	Globe Telegraph and Trust	10½	10⅝	10½	10⅝	4 12 4	Jan., Apr., July, Oct.	10⅝	10½
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15⅝	15⅞	3 16 10	" "	15⅝	15⅜
150,000	10	5/0	Great Northern	18½	19	18½	19	4 9 6	Jan., April, and July	..	..
£320,000	100	5%	Do. 5 per Cent. Debentures, 1933	107	110	107	110	4 10 11	March & September	..	..
17,000	25	1¾	Indo-European	41	43	42	44	5 13 8	May and November	43½	..
38,848	10	4/0	London Platino-Brazilian	6	7	6	7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108	111	108	110	5 8 1	March & September	..	..
10,802	8	8/0	Reuter's	7	8	7	8	5 0 0	April and October	..	..
5,381	£100 Cert.	£1¾	Submarine Cables Trust 6%..37/6 Bal. Ap. Coup.	115	120	116	121	4 19 2	" "	..	..
15,609	10	5/0	West African Telegraph	6½	7½	6½	7½	5 6 8	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101	104	101	104	4 16 2	March & September	103½	..
30,000	10	2/0	West Coast of America	3	4	3	4	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	..	..
88,321	10	6d.	West India and Panama	1¼	1⅜	1¼	1⅜	..	" "	1⅜	1¼
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½	9⅞	9½	9⅞	6 3 1	May and November	9⅞	9⅝
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8	9	8	9	6 13 4	" "	..	..
64,242	15	6/0	Western and Brazilian	8⅞	9⅛	8⅞	9⅛	6 9 7	" "	..	..
33,129	7½	1/8	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 7	" "	6⅞	6⅝
33,129	7½	4/0	Do. 5 per Cent. Deferred	2⅞	3⅛	2⅞	3⅛	..	" "	3	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	104½	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs. Series "B" 1910	103	106	103	106	5 3 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123	128	123	128	5 9 5	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
124,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛	⅜	⅛	⅜	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	1/16	1/16	1/16	1/16	7 18 2	Yearly	..	..
438,984	5	3/6	National	4½	4¾	4½	5	6 0 0	June and December	5	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½	14½	13½	14½	4 4 3	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13	13½	13	13½	4 8 11	" "	13½	13½
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109	111	109	111	4 1 1	January and July	110½	..
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	—	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	9½	10½	10	10½	..	—	10⅞	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	—	—
8,332	£5	..	House to House Electric	2½	3½	2½	3½	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5	5½	5	5½	..	—	—	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½	5⅝	5½	5⅝	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 1/16	3 1/8	3 1/16	3 1/8	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16	5 1/8	5 1/16	5 1/8	..	March	..	..
111,000	5	..	London Electric Supply	¾	1	¾	1	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½	7½	6½	7½	..	—	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4	5	4	5	—	—	..	..
18,680	£5	2/6	St. James' and Pall Mall	7½	8	7½	8	—	—	7¾	..
7,900	£5	7%	Do. 7% Preference	8	8½	8	8½	..	—	..	..
42,853	5	3%	Westminster Electric Supply (fully paid)	5½	6½	5½	6½	2 8 0	—	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	2⅞	3⅛	3⅛	3⅜	..	..	3⅛	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2⅜	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	5⅞	5½	5⅞	6 1 9	January and July	5⅞	..
12,139	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	4½	5½	4½	5½	..	—	5	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅝	2½	2⅝	..	—	2⅝	2⅞
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½	22½	21½	22½	5 11 1	February & August	22½	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104	106	104	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½	3½	2½	3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6	7	6	7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1/16	⅛	¼	⅛	..	..	..	..
78,349	5	2/9⅓	Swan United (£3. 10s. paid)	3	3¼	3½	4	9 12 6	May and November	3⅜	3⅛
37,350	12	12/0	Telegraph Construction and Maintenance	43	45	42	44	5 9 3	March and July	44	42½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103	106	103	106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅛	¼	⅛	¼	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½	3	2½	3	..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	..	..	..	..
50,000	£10	½%	City and South London Railway xd	2⅛	3¼	2⅛	3⅛	1 8 6	..	..	..

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THE ELECTRICIAN:

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NOTES.

In the publication of an article by Dr. J. Hopkinson and Mr. B. Hopkinson, which will be found in the present issue, we welcome a new worker in the field of experimental science. The present investigations of Dr. Hopkinson and his son, which were briefly alluded to at the British Association, set at rest what doubt remained as to the presence of magnetic viscosity or magnetic lag in iron, up to a frequency of 125 cycles per second. The conclusion which has been arrived at by these authors, that the hysteresis curve is the same for quick cycles as for slow ones is the more important, as it was arrived at by experiments with alternating currents, the shape of which departed widely from the simple sine curves so dear to many mathematical minds. Prof. Ryan made some of these sine functionists very uncomfortable, and now Dr. J. Hopkinson and Mr. B. Hopkinson display most erratic curves which suggest at first that some very queer dynamo was used. However, there is always Fourier's theorem to fall back upon.

But on closer examination of the conditions of the research we find that the figures accompanying the article do not at all indicate the character of the voltage curve of the dynamo used. The curves B only show the voltage impressed on the inductive resistance H, and must differ from the voltage curve of the dynamo in consequence of the voltage needed to force the current through the resistance R. This circumstance appears to us to explain the fact that the curves B in the various diagrams differ widely from one another. The accuracy of the results could, indeed, be tested by deducing the voltage curve of the dynamo from the curves A and B, and seeing whether it is the same for all the figures.

The practical investigation of hysteresis and of eddy currents has engaged the careful attention of Messrs. Evershed and Vignoles, and we hope very shortly to publish the continuation of their communication which appeared in these columns on October 15, 1891. These experimenters have held that no magnetic lag exists within the limit of ordinary frequencies. Their forthcoming article will treat, amongst other matters, of the creeping of the induction to a new value between two successive observations; and the difference between the observations of Dr. J. Hopkinson and Mr. B. Hopkinson by their two methods might be explained in this manner. The difference begins just after the iron has passed through its nearly unstable condition, and if left to itself a little, while the necessary manipulations of the instruments are made, the induction will rise slightly, and thus each step deviates from the true curve.

There are now several instruments by which dynamo makers may test the magnetic qualities of samples of iron, and one of the most simple of these, exhibited by Dr. H. E. I. G. Du Bois at the British Association at Edinburgh, was described in our columns a fortnight ago. An uncertainty may arise in the use of such an instrument as this, or the "permeameter" of Prof. S. P. Thompson, on account of imperfect contact with the end of the test piece. Dr. Du Bois provides an automatic magnetic plunger which will give a definite pressure on the end of the test piece, but careless surfacing or squaring of the end would render this useless. If the ends of the test pieces were shaped to a definite convex curve, or being fairly flat, were held between convex clamps, the contact would be practically the same each time, and allowance would be made as part of the air-gap of the instrument. But in testing iron wire and sheet, even convex or conical clamps could not be relied upon to make uniform contact unless the samples were carefully made up solid, and surfaced. The air-gap of the instrument, as shown at Edinburgh, would bear a little reduction, and it seems that a small gap, say of brass, might be introduced at each end of the test pieces, without shearing the axis of the diagram too far backwards. Careful surfacing of the ends would not then be necessary.

Prof. Ewing's magnetic curve-tracer had only assumed a practicable form shortly before the meeting of the British Association, and it was almost too early then to criticise it. The conditions which limit the speed of the instrument were not made quite clear. Prof. Ewing, in the discussion which followed his description of the instrument, repudiated any mechanical inertia, but did not claim a higher speed than 20 per second. It is clear that apart from the natural period of the strained wires, which may be very high, there must be some inertia in the mirror; he alluded, indeed, to "little ripples due to inertia of the working parts." It would seem that ripples such as those which are clearly visible in the lower part of the larger diagram, which were published on page 385 of our issue of August 12th, were due to the natural vibration of one of the wires, or to the mirror under the

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strain of the springs, and which, at two cycles per second, appear to correspond to about 70 vibrations per second. If the spot of light described a circle, the motion of the mirror would be continuous and gyratory; it must, however, in practice offer some opposition to sudden reversal of motion, and we should like to know to what extent this interferes with the running of the instrument up to 100 per second. Something striking ought to happen when the period synchronizes with the period of these ripples; but it ought to run smooth at still higher speeds.

THE efficiency of the modern first-class dynamo is as near perfection as need be, and its durability is but little less perfect. It is said to be expensive, but the profits in mere dynamo building are probably as small, if not smaller, than in the construction of any other high-class machinery. The real way of putting the case is, that most dynamos give very little output for the money, and the higher the class of design and workmanship, the less is the output per £1 and per lb. MM. REIGNIER and PARROT have recently made a dynamo which is said to give 32,000 watts at 500 revolutions, with a weight of only 1,600. In our Paris Notes, dated March 11, 1890, we gave some particulars of a machine constructed by MM. REIGNIER and BARY, which gave 10,500 watts at 1,800 revolutions, with a weight of 580lb. The armature of this machine resembles that of FRITSCHE, of which so much was expected some three or four years ago. There may have been structural difficulties in the way of this form of armature which is remarkable for what the French call "*puissance specifique*," but we understand that some progress is being made with the principle of "wave-winding." A brief account of the new machine will be found in our Notes, and a translation of a communication by MM. REIGNIER and PARROT to the Académie des Sciences upon the subject will be found in another column.

THE prize of five thousand francs—about two hundred pounds—which was awarded by the municipality of Paris to Prof. ELIHU THOMSON in the contest for the best electric meter, has been devoted by him to "serve for the development of the theoretical knowledge of electricity" by the offer of a prize for the best essay on one of certain appointed subjects. These will be found among our Notes.

THE custom of offering prizes for essays or other scientific work is a peculiarly French idea, and one which cannot, on the whole, be said to have elicited anything of great value. The best work continues to be divided between the commercial man, who is always with us, and the amateur, about whom Prof. SCHUSTER has recently made some trenchant remarks. Looking back over the past ten years, we find that in 1882 the Boidin prize of a gold medal and 3,000fr., offered by the Académie des Sciences, for the best essay on the Origin of Atmospheric Electricity was not awarded, as no sufficiently good work was sent in. In the following year, and again in 1886, they proposed the curiously-worded subject of "Perfection in each Important Point of the Theory of the Application of Electricity to the Transmission of Work." But only one memoir was sent in, and without success. In 1884 the Société Nationale d'Encouragement pour l'Industrie Nationale offered a prize of the same value for an essay on the transmission of "natural forces," one of 1,000fr. for the indication of temperature at a distance, and 3,000fr. for "strong and simple apparatus capable of announcing safely, regularly, and automatically, the passage of a train at any distance." The KING OF THE BELGIANS made the handsome offer of a prize of £1,000 annually, and in alternate years for international competition. The subject in 1886 was "The Progress of Electricity Applied to Motive Power and Illumination: its Applications and Economical Advantages." In 1887 the Société d'Encouragement set the subject, "A small motor designed for a family workshop, to be worked separately, or to be connected with a central factory," and offered 2,000fr. as a prize, and repeated the subjects of transmission of power, train indicator, and thermometer indicator, with a prize of 3,000fr. each, and added another prize of the same value for the discovery of a "perfect process of transmitting to a distance motive power to agricultural machines." In 1888 the Belgian Society of Electricians offered 250fr. for the best essay on the elementary principles of electricity. We hope that the Elihu Thomson prize will do more than these.

THERE are a good many cases in practical work in which the principles of maxima and minima might be applied, if it were not that the mathematics are too difficult for ordinary use. By plotting a few simple cases a curve can generally be drawn which shows the general position of the maximum at a glance. A small departure from the maximum in some cases does not matter; as, for example, the best point of incandescence of a glow lamp, because the curve being tangent to the line of maximum economy, it does not rapidly approach or depart from it. Several curious problems of this sort arise in driving dynamos, especially on a small scale, where the conditions are not easily recognised and where, too often, the arrangements are guessed. Up to a certain point, for example, by increasing the size of the fly-wheel of a gas engine, or by decreasing the size of the pulley on the dynamo, the faster will the latter be driven; but after this point is passed the engine will be pulled up in a way which perplexes the uninitiated, and similar puzzles arise in connection with the strength of the fields of shunt-wound dynamos.

IN some cases the conditions for exceeding the maximum so rarely arise that serious waste may ensue from neglect of the possibility of a decrease. It is so obvious that two lamps on a given circuit connected to a supply at 100 volts give twice the light of one, and that three will give three times the light, that it might be thought that if the lamps be indefinitely increased the total light will increase also. The usual limit would be the heating of the conductor. But on a large scale the fall of volts will become serious long before any serious heating arises. Such a case exists in a large building in London. The terminals of the supply company provide about 105 volts at no load; but owing partly to the resistance of long mains within the building, and partly to that of the meters and the feeder in the street, the volts at the lamps fall to 100 when about 220 amperes are passing,

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and matters get worse with heavier loads, until at 500 amperes or so the lamps get only 94 volts. The sheer waste of 5,500 watts, or about three shillings an hour, is bad enough; but this is a trifle when it is remembered that 100-volt lamps run at 94 volts give only 0·62, or $\frac{5}{8}$ of their proper light. At about this point, adding more lamps does *not* give any more light, and 150 lamps of 16 candle-power might be turned off without affecting the total amount of light, but saving the cost of current which at this rate comes to the equivalent of nearly one shilling per unit. Until recently, gas engines have been used to assist in parallel, and the volts were easily kept up to 100. In order to "economize," under a new management these have been stopped, and great complaints are made of a huge "leakage" somewhere.

The calculations on electric stoves and electric smelting which we reproduce from the *Engineering and Mining Journal* in another column are suggestive rather than convincing, and may form the basis of further enquiry rather than guides for practical work. It is arguing in a circle to show that to heat by electricity generated by a steam engine would take more than twenty times as much coal as to heat by the direct combustion of the coal, for it is perfectly well known that a steam engine only yields about one-fourteenth of the energy of the the coal, and further losses must occur in transformation from mechanical into electrical energy. The performance of the electric stoves is worth recording, but the calorimeter method of estimating it—we cannot say measuring it—is open to several objections. It is in the production of high temperatures not easily attained by other means, and more especially in the concentration of the heat by generation at the very place where it is required, that electric heating promises to be most valuable.

Moscow Electrical Exhibition.—The Electrical Exhibition at Moscow was opened on the 27th ult.

Wurtemberg.—The central station at Wangen, equipped by the Maschinenfabrik Oerlikon is to be opened on November 15th.

Post Office Telephone Instructions.—An erratum occurs in the last paragraph but one of these instructions, and was reproduced in our last issue. For resistance of primary 5ω, read 0·5ω.

Valparaiso.—The local gas company has decided to build an electric central station in the best part of the town, and has entrusted the work to Messrs. Siemens and Halske, of Berlin.

Personal.—Mr. Reginald John Jones, M.I.E.E., A.M.I.C.E., desires us to state that he has renounced the surname of Jones, and will in future assume and use the surname of Wallis-Jones.

The Telephone and Local Authorities.—The St. George's-in-the-East Board of Guardians have asked the Local Government Board to place the whole of the casual wards of London in telephonic communication.

Fatal Accident at Cologne-on-Rhine.—A workman was recently killed at the Municipal Central Station at Cologne-on-Rhine. The whole of the floor of the regulating room has been carefully insulated, and the deceased man was wearing rubber gloves at the time of the accident, so that, as he was alone, it seems difficult to determine how it was that it occurred.

Technical Classes.—Information about the courses of instruction in mechanical and electrical engineering at the Royal College of Science, Dublin; the University of Glasgow, Durham College of Science, University College of North Wales, the Municipal Technical School, Manchester; and the People's Palace Technical School, will be found in the advertisement columns of the present issue.

Coast Communication in the Isle of Man.—A line of telegraph has recently been completed between Ramsey and the Admiralty signal station at Port Cranstal, six miles north of Ramsey. A wire has also been set up from Peel to the Admiralty station on Peel Hill. A survey has been made for a telephone line to the Admiralty station on the south of the island, and when this is finished the whole of the coastguard stations on the island will be in telephonic communication with the postal telegraph system.

Hastings.—The Hastings Town Council decided on Friday last to light the whole of the Esplanade from the Fish Market to the end of West Marina, a distance of three miles, with electric light arc lamps 80 yards apart. At present the front is illuminated jointly by electricity and the "Whitehall" gas lamp.—The local Electric Light Company undertake to provide, for three years, 52 arc lamps, 80 yards apart, at £25 per lamp per annum. The total cost will be £1,300, and it is estimated that the new system will effect a saving of £68 a year on the present charges.

The Marseilles-Oran Submarine Cable.—On the 14th of last month the steamer "François-Arago" (late "Westmeath") left Calais, having on board the Marseilles-Oran cable. This is the first time a French ship has been entrusted with a cable made by a French firm under French supervision. This cable has been made to the order of La Société des Téléphones. The conducting wires were made at Bezons, and the external casing at the Calais works, which are situated close to the Carnot basin, so that the cables can be passed directly from the tanks on board ship. These works, which employ 300 hands, have already turned out over 3,000 miles of cable.

High-Speed Electrical Transit.—Every now and then a new scheme is brought out, says *Industries*, for running trains at a speed of 100 miles an hour or more by electrical means. An express locomotive develops, say, 1,000 H.P. at 60 miles an hour, yet the rapid-transit enthusiast proposes to work with about a quarter of this power, and to obtain nearly twice the speed. The proposal generally consists in a scheme for using very light rolling stock and very efficient motors. It would be well for those who are working at such schemes to obtain trustworthy information as to the air resistance of an ordinary train, and to find from that what power would be necessary to drive one at 100 miles an hour through still air, or against a head wind.

Exports of Telegraphic Apparatus.—The Board of Trade returns for last month are not so disappointing as those of July, either as regards the falling off in the total exports, or the decrease under the head of metals and articles manufactured therefrom. The figures relating to the exports of telegraphic wire and apparatus connected therewith still, however, compare very unfavourably with previous returns. The aggregate exports for the past eight months of this year are valued at fully £500,000 less than in the corresponding period of 1891. The following is a statement of the exports, in comparison with the corresponding figures for 1891 and 1890:—

	1890.		1891.		1892.
January to June.....	£721,712	.....	£984,530	.....	£675,835
„ „ July.....	56,575	.....	150,754	.....	25,906
„ „ August...	55,601	.....	112,690	.....	29,755
Eight months	£833,888	.....	£1,247,974	.....	£731,496

A Unique Water-Power Installation.—A unique water-power installation, so far as head is concerned, has recently been carried out by the Pelton Water-wheel Company in one of the Comstock mines at Virginia City, Nevada. The wheel is 36in. diameter, and is made of a solid steel disc, with the buckets riveted on to the periphery. It is running under a vertical head of 2,100ft., equal to 911lb. pressure; 460ft. of this head is obtained from a pipe line, and the remaining 1,640ft. from the shaft, down which the pipe line is run to the Sutro tunnel level, where the power station is located, and through which the water discharges after passing over the

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wheel. The wheel runs at 1,150 revolutions, with a peripheral speed of 10,804ft. per minute, or about 120 miles per hour. A nozzle tip, ½in. diameter, gives under above conditions 100 H.P.

The Influence of the Electric Light on Paper.—In a communication "On the influence of Incandescent Electric Light on Paper made from Wood-cellulose, and its Deterioration through Exposure," Mr. J. Wiesner states that he finds that after exposure of 552 hours to a light of 144 c.p. no yellowing takes place, whilst with gas light after 240 hours of 50 c.p. a slight degradation of tone is noticeable. It is to be observed that the action of light may proceed for some time without producing any visible effect; but on treating such paper with potash solution of such a strength as only to give a faint yellow colour with unexposed material, a brownish stain is developed. Incidentally he mentions that whilst direct sunlight after a few hours causes a change in paper made from wood pulp, bright diffused daylight can only effect a similar change after several days.

The Printing Telegraph in a Steel Mill.—The Illinois Steel Company, of Chicago, has introduced a printing telegraph system in its mills, by means of which the men at the reheating pits can inform those at the finishing end of the mill as to the heat numbers of the ingot, the ingot numbers, and the number of rails to each ingot, so that the proper number may invariably be stamped upon each rail that leaves the mill. In addition to these numbers the "pit" and "hole" designations are also despatched by the same means. It is stated that the mechanism works in a very satisfactory manner. The transmitter is in charge of one of the men at the reheating pit, and the receiving instrument is in charge of a boy, who reports on a blackboard for the use of the stamper the different numbers and letters as they are printed on the tape by the receiving instrument. The distance between the two is about 350ft.

Aluminium.—The variety of new uses which, under the influence of the glut in the aluminium market, caused by the advent of the electric process, has been found for aluminium is very astonishing. We are now told that it has been found that powdered aluminium can be burnt to as good effect as magnesium for lecture-room purposes, while it is considerably cheaper. On the other hand, this aluminium light is not so actinic as magnesium light. The powdered aluminium cannot be satisfactorily burnt in an ordinary spirit lamp; but the best result is obtained by using such a lamp fitted for receiving in the middle of its flame a supply of oxygen, and into which the powdered metal is simultaneously projected by means of a compressible india-rubber ball. The best light was secured by burning in this way a mixture of 100 parts of finely-powdered aluminium, 25 parts of lycopodium, and 5 parts of ammonium nitrate. It has been erroneously stated that this mixture leaves no smoke.

Electric Lighting for Lightships.—The U. S. Government lightship, No. 51, allotted to Cornfield Point, is a new departure in several respects, being provided, amongst other things, with steam-propelling machinery, and a complete electric lighting plant, which is situated in the after part of the main deck house. The plant consists of two horizontal high-speed engines, developing 8 H.P. with 70lb. of steam, from which power is transmitted by two Evans friction cones to two compound-wound Thomson-Houston dynamos, supplying electricity to 8 100-c.p. and 20 16-c.p. lamps, the former lighting the two signal lanterns situated on the masts, 49ft. above the deck, and the latter distributed about the vessel. Either of the dynamos is capable of lighting the whole vessel. The signal flashes are regulated by an automatic make-and-break apparatus in the engine room, and can be adjusted to give any desired combination of signals. The double system of wiring is employed throughout.

Lighting of the House of Commons.—During the present recess it is intended to make a considerable further extension of the system of electric lighting at the House of Commons. Under Mr. Plunket's *régime* most of the rooms on the basement and on the ground floor of the building, the various smoking and dining rooms, the library and tea room, the Ministers' private apartments, &c., have been furnished with incandescent lamps in substitution for gas, and upstairs the new illuminant has been introduced into the reporters' gallery and also into two or three of the committee rooms. The committee corridors are, however, still lighted by gas, and in the bulk of the committee rooms the only resource on dull and foggy days is the old-fashioned colza dirty and smelly lamp. It is not proposed to make any alteration in the lighting of the House itself, for the elaborate arrangement of gas lights above the roof took many years to bring to perfection, and is connected with the ventilation.

The Regnier and Parrot Dynamo.—According to a Paper by Mr. James Chappuis, published in *Le Génie Civil*, Messrs. Regnier and Parrot have made a machine weighing only 1,600lb. which gives 32,000 watts at 500 revolutions. This dynamo has a field with four pairs of magnets arranged so that the two opposite poles are north and south as in an alternating current machine. The armature is the same as that of Fritsche or Deroziers in principle, but is not made up entirely of copper or of iron, but of a combination of both. Each armature strip is made up of a strip of soft iron with copper on each side of it. The connections are made by means of copper pieces resembling commutator sections. The armature is, of course, very thick, as the iron carries the induction easily. The details of this machine are as follow:—The armature has 264 turns, and each conductor carries 200 amperes; the output is thus 800 amperes and 40 volts at 500 revolutions. The armature conductors are half copper and half iron, and one turn has an area of field of 47 square inches. The insulation is 0·055in. between the conductors, but the makers expect to reduce it to 0·016in. Each electromagnet has an area of 29 square inches, but the armature iron in use under each magnet pole is only 9·6 square inches. The armature is 27in. diameter outside. Commenting upon this machine, *Industries* observes that from this it will be seen that the extraordinary result is obtained by having an enormous number of ampere turns on the armature, namely, 13,200. As the armature is well ventilated there can be little heating, but further information should be forthcoming as to the sparking. There must also be some waste of power in the armature due to its lamination not being in the right direction.

Electrical Nomenclature.—The comments on electrical subjects which appear in the *Journal of Gas Lighting* are generally none the worse for coming, as a rule, about a fortnight or three weeks after the events to which they refer. From this week's issue we extract some observations which we recommend to the attention of some of our readers:—There was a somewhat interesting, although apparently fruitless discussion, at the recent British Association meeting upon the nomenclature of certain electrical units. The various applications of electricity to which the world is now being treated are attended by the appearance of many phenomena, attesting the operation of the unknown form of energy, which, for the want of a better word, we may term "symptoms." A closed wire circuit, and the dynamo which keeps up the supply of electricity in the circuit, and many things lying within or near the circuit, manifest a multiplicity of symptoms indicative of the activity or whatever it is that is going on within and about them. It is the function of our professors of physics to bring these symptoms to book as fast as they are distinguished; and in order to do this, it is necessary to name them. Unhappily, the language of men does not contain any undistributed reserve of words which can be drawn upon for the nomenclature of newly-discovered things, whether the things happen to be mountains in Africa, strange worms in mud, or manifestations of what is called electricity. Consequently, terms have to be created to fit the new things; and when the nature of these is not fully understood, the most expressive word that can be applied to them remains, as Matthew Arnold would have said, language "thrown out" towards the Unknown. If the word happens to stick to the thing, people grow in time to talk about it as though it were the thing itself, which is the way to confusion. The electricians have great difficulty in regard to their nomenclature. This is hardly to be wondered at, since, to the initial difficulty of the unknowableness of the things sought to be named, they have added the further obstacle of conspicuous want of tact in their suggestions of words for them.

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NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 485.*)

17. Paying out (*continued*).—In some of the earliest cable-laying expeditions accidents due to insufficient brake power, or insufficient number of turns of cable round drum have occurred. If the grip of the cable on the drum is not sufficient, it will continue to pay out, even though the drum is pulled up dead by the brake. Mr. J. W. Brett relates an accident of this kind while laying the 1855 and 1856 Mediterranean cables between Spezzia, Corsica, Sardinia, and Bona, when two miles of cable ran out of the ship in five minutes, flying round even when the drum was brought up dead. He attributed it to the fact that the cable was only taken three times round the drum, and that being of so large a type, there should, at least, have been five turns to afford sufficient gripping surface on the drum. With improved methods and machinery accidents of a like nature are happily of very rare occurrence, and the writer only recollects one case within several years, this being the fracture of a brake band. On this occasion the engineer in charge of the gear managed to throw in the clutch of the train of gear in time to avert a seriously rapid uncoiling of cable from tank. Life lines are hung from eye-bolts, fixed in the angle iron round top of tank at short distances, by means of which the men at work inside can make good their escape in case of the cable taking charge. Should a loop or twist occur, which might form into a kink if not straightened in time, the ship is stopped immediately. On cable ships special smartness is necessary in handling the ship. On some ships, as, for instance, on the "Electra" (Eastern Telegraph Company), in addition to the ordinary hand-wheel for moving the links over for reversing

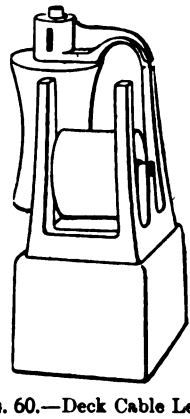

Fig. 60.—Deck Cable Lead.

main engines, which takes an appreciable time, there is another lever which, when operated, admits steam to a small vertical cylinder, the piston of which acts on a water ram, and moves over the links rapidly. In fact, with this system, known as Brown's reversing engine, the links on both high and low pressure eccentric rods are shifted over in little more than the time it takes to pull over a lever. An electrical circuit to a bell on the bridge is also arranged to be closed automatically whenever the links are over to "astern" when the orders on the telegraph are "ahead," and *vice versâ*. This arrangement is not altogether satisfactory to the engineer, as, however smartly he may follow his orders, he is frequently obliged by the position of his cranks to reverse for a moment in order to carry out the order.

On its way from the tank to the drum and paying out sheave the cable passes over guide pulleys or leads placed at suitable distances on deck. One of these is illustrated in Fig. 60, in which there are a pair of rollers on axes at right angles. The affair is placed with the vertical pulley on the side towards which the cable bears; the course of the cable over deck not being straight along the whole distance. Guides are provided on either side of the rollers to keep the cable from shifting.

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Surface currents and tides have a marked effect on rate of paying out. The rotometer may register as much as eight knots of cable going out per hour, if the set of the current is with the ship. This is, of course, not too great a speed if the current is carrying the ship along three knots over the ground, independently of her own speed of five knots, through the water; but the effect must not be mistaken for paying out too much slack and strain thrown on the cable by setting up the brake. Under ordinary conditions, when the tide or current is not flowing in the ship's course, the fact of eight knots leaving the ship when she is only moving five, would, of course, mean 50 per cent. more slack than necessary, and great waste of cable. The cost of cable when new being over £200 per mile, it is an important matter to pay out only just what slack is necessary for laying without strain, and for repairs. The strain or tension on cable indicated by the dynamometer as ship pays out should represent little more than the weight of the length of cable in water suspended from ship, which varies according to depth and type of cable. With light cables in 1,000 fathoms the strain allowed is about 12cwt. to 15cwt. The brakesman watches the movements of the dynamometer pointer on the scale, and if any sudden strain appears, such as on entering deeper water,

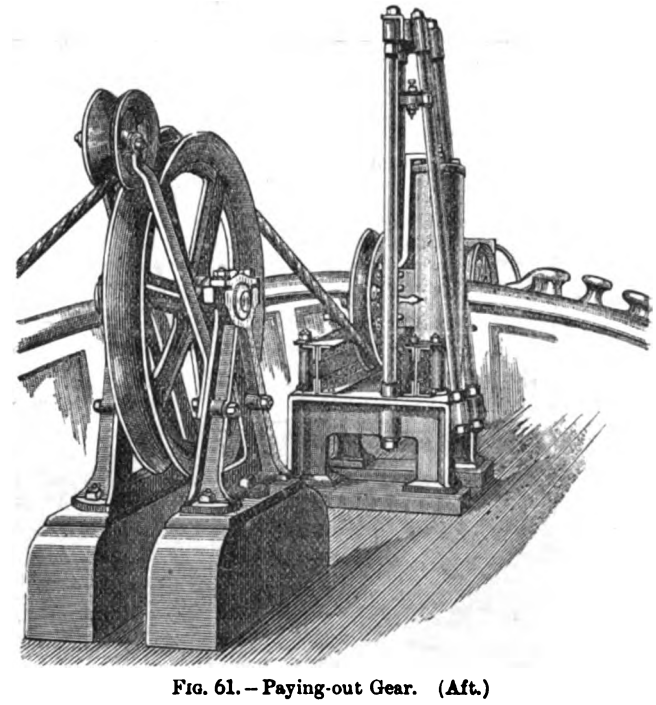

Fig. 61.—Paying-out Gear. (Aft.)

he slacks his brake a little to take off the extra strain. If, on the other hand, he finds the strain reduced, such as would happen in a belt of shallower water, he checks the cable to prevent too much slack going out. The speed of ship through the water is ascertained by the log, but this gives no idea of her speed over the ground as affected by tide or leeway; and while the direction and force of the tides are generally known, and the ship's course can consequently be kept straight over ground by making due allowance, it is a more difficult matter to make any correct observation of the surface currents, unless any land is in view to go by.

The dynamometer, leading pulley, and stern sheave, over which the cable finally rides into the sea, are illustrated in Figs. 61 and 62. It is usual to fix these on the port or starboard quarter, to give the cable as straight a course as possible from the forward drum. In large cable-laying steamers, which pay out over stern, the drum and brake are fixed aft, and a steam engine coupled to them. With the steam gear a cable can be picked up again, on the same drum, if a fault has been payed overboard, without the necessity of bringing cable end round outside ship over bow sheave to picking up drum. In repairing steamers the quarter deck is of the general appearance shown in Fig. 61, the view there given representing that on the cable ship "John Pender" (Eastern Telegraph Company).

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The modern type of cable ship is well represented by the "Electra," belonging to the Eastern Telegraph Company.

Built of steel in 1884 by Messrs. Robert Napier and Sons, of Glasgow, she measures 230ft. in length, 32ft. beam, by

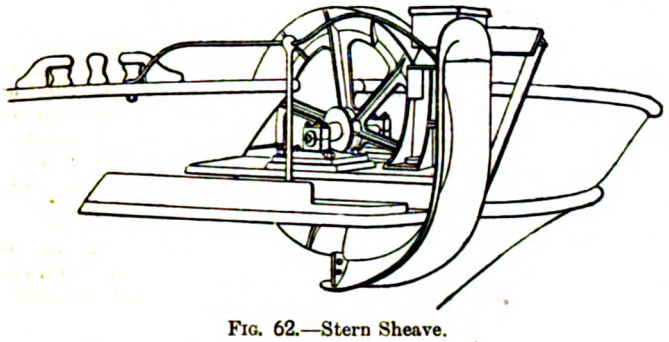

FIG. 62.—Stern Sheave.

24ft. depth from awning deck, and can steam 11 knots. In regard to the cable gear, which was made and fitted throughout by Messrs. Johnson and Phillips, it is noticeable that the picking up machinery forward is, together with the double-cylinder steam engine driving it, fixed on the main deck, while the starting and reversing levers and brake wheel are taken through on to the awning deck. This is a most convenient arrangement, and better than having all the weight on the upper deck.

The upper part of the cable drums and brake wheel appear through openings in the awning deck, so that the course of the cable as it passes the gear can be fully observed while there is perfect control of the gear on this deck in full sight of the bow sheaves and dynamometer. Two dynamometers are fitted forward, one for each drum, for picking-up and paying-out over bows, and triple bow sheaves are fitted. Steam is taken to the gear from the main and donkey boilers so that the gear can be worked in port if cable required to be turned over. A special advantage to a cable ship is the addition of a separate circulating pump for keeping main condensers cool during stoppages or slow-speed runs; and on board this steamer one of J. and H. Gwynne's centrifugal pumps, coupled direct to small vertical engine, has been fitted for this purpose. The dimensions of this vessel's tanks have previously been given in para. 10 on capacity of tanks. The smallest tank (No. 1 forward) is generally used for coiling grapnel rope, while No. 2, the largest, and No. 3 are the two most generally in use, and will carry 150 miles of mixed cable when required. The two dynamos and the direct-coupled engines for supplying electric light on board, are by Messrs. Clarke, Chapman and Co., of Gateshead, and have been conveniently fixed on main engine-room floor, with switchboard on wall adjoining. Nightwork on deck is carried on by the aid of incandescent lamps arranged in groups of six and fitted under yard arm reflectors, one such group throwing light immediately under the bows. When making for the buoy by night, also, the search light on the bridge is found of great use. The illustration herewith produced (Fig. 63) of this fine vessel of 1,096 tons, whose work is chiefly in the Mediterranean waters, gives a fair idea of her proportions and build, characteristic also of the cable ships "Amber" and "Mirror" of the same Company, and the "Recorder" of the Eastern Extension Telegraph Company.

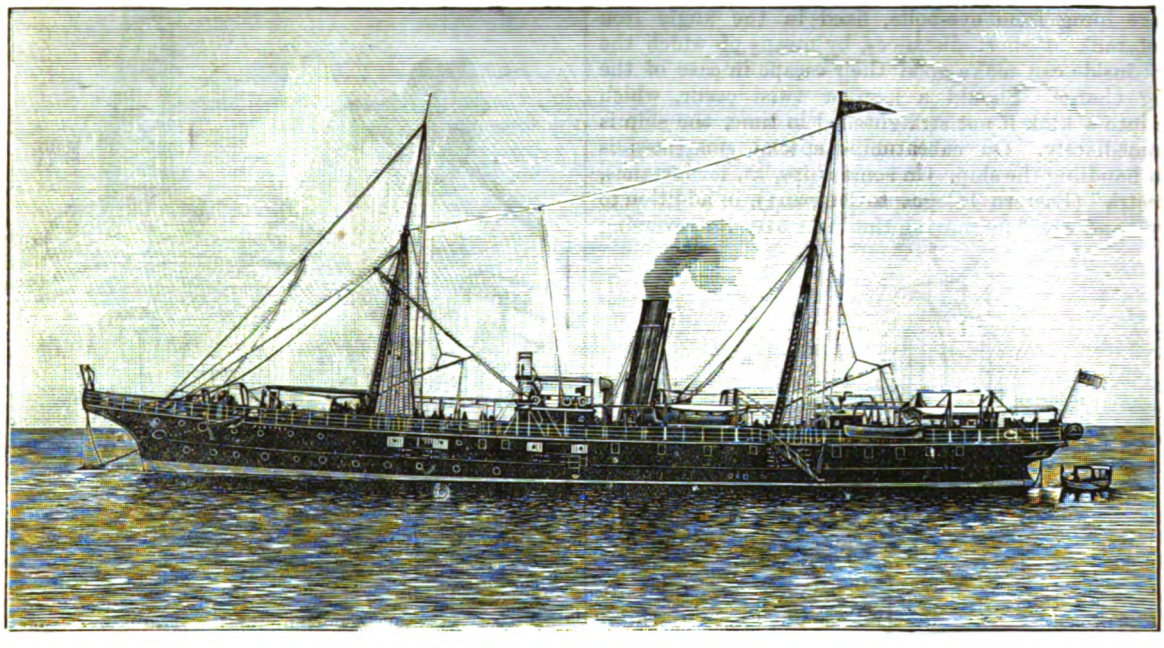

FIG. 63.—Cable Ship "Electra" (1,096 tons).

(To be continued.)

THERMAL CONTROL FOR ARC LAMPS.

Several attempts have been made to dispense with electro magnets in arc lamps with the view of simplifying the mechanism and giving a more definite and regular feed. Mr. S. E. Nutting has constructed a lamp in which a drum is geared to the rack of a carbon rod. This drum acts as a brake-wheel, allowing the carbon to descend slowly, but instead of applying the brake by means of an electro magnet, he employs a very strange device. A deep groove in the circumference of the drum is filled with stearine wax, and the end of a copper pin wound with fine wire is imbedded in the wax. The pin is fixed radially, two-thirds of its length is wound with wire, and the greater part of the bare end projects into the wax. The resistance of this winding is about 150 ohms, and a resistance of 500 ohms is placed in series with it, and the whole arranged as a shunt across the terminals of the lamp. It is found that the copper pin heats up under the current, and melts its way regularly through the wax, which closes up again behind. The depth to which the pin entered mattered little, whether much or little wax was melted the arc remained the same. The arrangement was said to work very well, and the lamp could be struck or rattled about without disturbing the feed in any way. The sensitiveness of the feed is due to some extent to the fact that the heating is as the square of the current. Such lamps have worked continuously for months.

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Mr. W. E. Irish, of Cleveland, Ohio, has attacked the problem of controlling the feed of an arc lamp by heat in a different way. He calls his invention a thermo-electric arc lamp, but there is no thermo-electric effect properly so called. The upper carbon descends by gravity through a differential clutch, and the lower one is forced upwards by mercury. A lever pivoted to one of the side rods controls the clutch, and this lever is moved by a "thermal strip." It is not clear from the description on the photographs which we have received whether this is a compound or bi-metallic strip; but as it is coiled in a long spiral, we presume that this is the case. When the current enters the lamp it passes through this strip, causing it to expand. This raises the upper carbon by means of the clutches, but as the arc lengthens the current falls off, the strip contracts, and the clutches allow the carbon to feed. Mr. Irish provides a magazine of carbons, and claims that these can be fed in both from above and below without any intermission, leaving no ends or stumps.

The drawback to most of these admirably simple arc lamp mechanisms is that they will not automatically compensate for any irregularities in the quality of the carbons. When a soft spot gives rise to a "blower," the arc ought to be lengthened, and there should be some means of doing this in case of an accidental over-feed.

AN IMPROVED BATTERY ZINC.

Under the name of the D'Infreville Wasteless Gravity Zinc a very ingenious dodge for preventing the waste in stumps of zinc battery rods has been introduced in New York. The invention consists in shaping the zinc so that a number of pieces

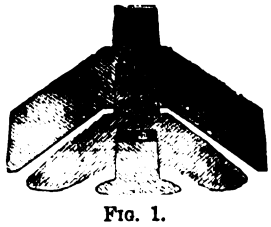


Fig. 1.

can be connected together by conical plugs and holes, and thus, a partially consumed piece may be connected to the bottom of a new casting. Every piece of zinc thus introduced into the battery may, therefore, be entirely consumed. In Fig. 1 a new zinc and two old ones in successive stages of consumption are shown in section, and Fig. 2 shows the arrangement of the battery. The zincs are firmly united by a few taps with a hammer.

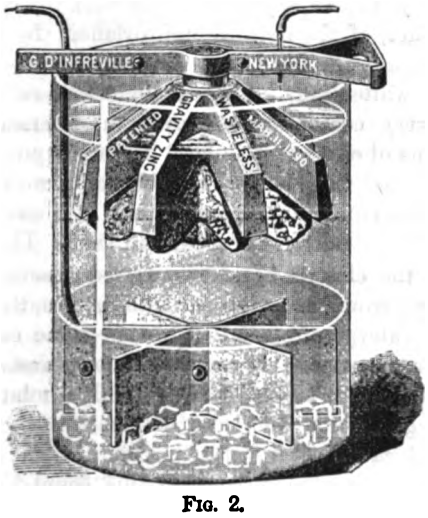


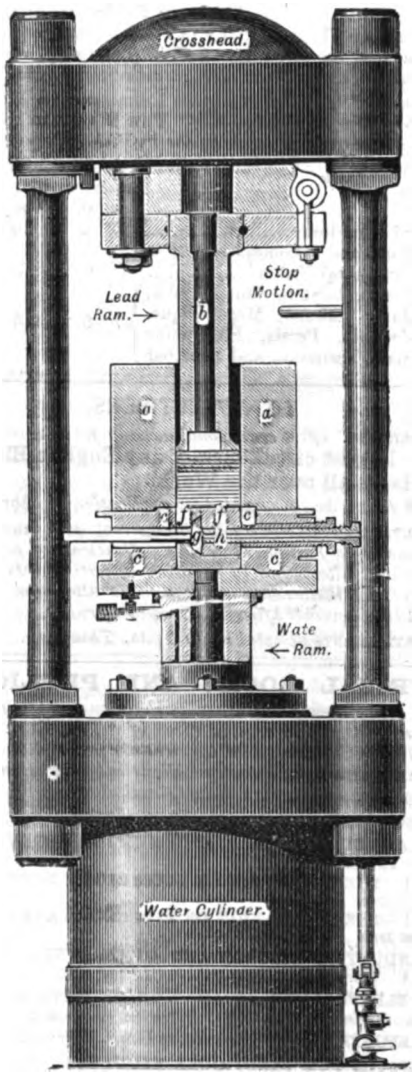
Fig. 2.

If it is found to be worth while to joint waste ends of arc carbons together by a patented process as is done at Concord, this system of "wasteless" zincs should prove to be relatively more economical.

PATENT MACHINERY FOR LEAD AND CABLE TRADES.

We illustrate herewith special machinery designed for the covering of electric cables with lead or other metallic substance, and for the manufacture of lead pipes, which is manufactured under patents owned by Mr. Alexander Wylie, of Messrs. J. and W. Weems, Perseverance Ironworks, Johnstone, Glasgow.

The illustration shows the general arrangement of the hydraulic lead press. The lead container is filled with lead or other metals, to be operated upon by either a hollow plunger for ordinary lead pipes or by a solid plunger for electric wires and cables, and in order to prevent the cable from being injured by heat specially-designed water chambers are provided allowing of a continuous circulation of cold water round the hollow block through which the cable runs. The rings or dies requisite for regulating the thickness of covering are placed in the hollow block, and the guiding cores are secured by regulating screws to the container. These guiding cores are either hollow or double cased to allow of



the flow of cool water previously referred to. To prevent the metal passing through the side of the hollow block the core is screwed up against the regulating ring or die, the cable is passed through the core, and when the metal is solidified in the first charge the core is unscrewed back as desired to allow the metal to pass round and cover the cable. By this means the cable is only exposed at the point of contact, a feature the importance of which cannot be over-estimated. The improvements claimed by Mr. Wylie are (1) the container (*a*); (2) the plunger (*b*); (3) the cellular base (*c*) with the water chambers; (4) the two-part core and die seat (*f*), and the conical guide (*h*). By means of the latter the regulating die (*g*) is secured in position, the core seat supporting the guide and completing the whole. By this machine lead-covered cables in continuous lengths are manufactured, with any required thickness of covering, and of any diameter between ⅛in. and 3in.

A number of these machines are in use by the leading makers of lead-covered cables in this country and abroad. The lead presses for making lead pipes, lead-encased tin pipe, and for solid block tin pipe are at work in all the principal lead works at home and abroad.

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FIRE RISKS AND RULES IN AMERICA.

The subject of fire risks, insurances, and rules and regulations for wiring, turns up from time to time, and it is safe to say that on every occasion the result is a strengthening of confidence in electrical work. The insurance companies are beginning to bestir themselves in the United States, and a meeting of "electrical insurance experts" has been held for the purpose of discussing a uniform set of rules for electrical work. The subject of fire risks in electric lighting has been brought before the American offices on several occasions by other associations, but no spontaneous meeting of any importance appears to have been held by them. We understand that during 1889 there were 119 fires due to electrical causes in the whole of the United States, and that in the following year there were only 73. This decrease may be traced to two tendencies: one, of bad insulation to break down and thus by degrees wiping out bad work by conflagrations, and the other, of the natural improvement in the quality of materials and workmanship. The insulation consisting of cotton and white lead, known as underwriters' wire, was at one time very commonly employed in America, and owing to conditions of climate it sufficed for many purposes, and is, we believe, even now used with safety for some interior work, although it was unanimously condemned at a meeting of representatives of the Edison Companies in 1887. This trust in the dryness of the climate has, however, led to serious accidents, and, jumping from the frying-pan into the fire, the non-inflammable non-waterproof insulation has, in some cases, been exchanged for a covering which will, indeed, resist damp, but, consisting chiefly of tar and wax, is highly combustible. There has been a great improvement of late both in the manufacture of insulated cables and wires in the United States, since several varieties are imported into this country, and some of them are found to satisfy the most stringent requirements.

We find the American journals teem with descriptions of improved contacts, switches, and other safety devices. Glancing through the last number of the *Electrical World* of New York we find a sufficient number of examples to show which way

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the wind is blowing. It is true that a wire covered with woven canvas is illustrated among the advertisements on the first page, but it is in company with four other advertisements, three of which claim high insulating qualities. The next two pages contain seven claims for mica, together with a china cut-out; further on is a patent insulating material, then hard rubber, slate for switchboards, then a relapse into wood rosettes and cleats; but soon after come porcelain insulators, porcelain base switch, weatherproof wire—whatever that may be—and porcelain lamp sockets. At the end of the paper we find more porcelain, kerite, mica, okonite, another porcelain cut-out, general porcelain fittings, special cut-out for motors, &c. So much for the advertisements which may be taken as a fair guide of what is going on. In the body of the paper we find an article on tests of fireproof wire, a ceiling cut-out—apparently porcelain, a "bug" cut-out, improved insulator pin, a notice of an Insulator Company, and a protest of the New York Board of Fire Underwriters against the trolley system. Among the patents are two safety switches, armature insulation, safety fuse, and a new insulator. This is a pretty good list for a single number taken at random, but to it we must add the announcement of the meeting of insurance experts to which we have already alluded, an article by Mr. G. Binswanger, on "How Fire Losses are Prevented in England," and two editorial notes on the subject.

Mr. Binswanger begins by expressing surprise that the insurance companies in America charge a special premium for buildings in which electricity is used; but at the conclusion of a long letter devoted almost entirely to the praises of the Phœnix Office and its electrical inspector, he admits that the "fittings, such as switches, cut-outs, &c.," which he has received from America, "are so poor from an electrical point of view, according to our notion, that no inspector of central stations or fire officer would allow them to be used in England." The insurance offices in the two countries have taken very different courses of action with regard to electric lighting. Here regulations were imposed which were highly unpopular, not so much on account of stringency, but by reason of their vagueness and need for separate interpretation for each job, the interpretation often coming only after the work had been done. In America, on the other hand, the companies did nothing, but merely raised the premiums. One result was the establishment in May, 1890, of the Electrical Mutual Insurance Company, which provided for intelligent inspection. It took risks amounting to $2,897,587 last year, and did not incur the loss of a single dollar. When brought into competition with this Company other offices reduced their premiums to one-half. The Fire Underwriters' Association of Philadelphia insures more than 5,000 buildings supplied with electric light and power, and during last year there was not a single fire which could be attributed to electric wires. Under these circumstances, we can hardly agree with Mr. Binswanger in his general advice to the American nation. "In my opinion," he writes, "the best way to remove the difficulties of which you speak is to get an authority in America like Mr. Musgrave Heaphy."

Rules for insulation and proper erection of electric work have been considered by the National Electric Light Association, a body which appears to successfully combine the most useful features of our London Chamber of Commerce, British Association, and Institution of Electrical Engineers, but their attention has been directed chiefly to the protection of high-pressure, arc-light circuits. If the fire offices of the United States can agree upon a single set of rules, self-explanatory, and with intelligent specification of work and material, they will have done more than ours can accomplish.

The introduction of well-designed fittings is evidently making rapid progress in America without the assistance or compulsion of insurance offices, and they have makes of insulated wire which, if not up to the best qualities of our vulcanised rubber, are amply sufficient for all ordinary requirements, especially in a dry climate. From the editorial note in our contemporary, we understand that the nonconformity of the rules, rather than their severity, is the present trouble. This is a smaller evil than the nonconformity in the interpetation of one important set of rules, which has caused so much annoyance with us. It seems under these circumstances that there is not much to complain of. Americans led the way in electric lighting at a pace which we did not care to follow, and now they are finding disadvantages of cheap and nasty work, and have already adopted many of the precautions which have been initiated on this side of the Atlantic for low-pressure work, and are at the same time improving the high-pressure arc circuits which have given rise to most of the accidents. By thus allowing matters to right themselves they seem to be taking the best possible course.

REVIEWS.

Formulaire de l'Electricien. By E. Hospitalier. Dixième Année. 1892. (Paris: G. Masson.)

With engineering pocket-books compactness bears the same relation to all other considerations that charity does to all the other virtues. The ideal pocket-book should contain nothing but clearly arranged well-digested tables, formulæ, and tests likely to prove of use to the engineer; illustrations, other than curves and diagrams, should be tabooed, and the limited dimensions of the average pocket should not be lost sight of. The "Formulaire" for 1892, with its 400 odd crown octavo pages of closely printed matter and its goodly muster of formulæ, many of which perhaps ought to be, but certainly never are, used by the engineer in the flesh, scarcely comes up to standard requirements. However, the author in this respect errs in excellent company. Slightly expanded and printed in larger type, the "Formulaire" would be an addition to our list of practical text-books; considerably compressed it would take a high rank among the numerous electrical pocket-books which have issued from the Press.

To descend from generals to particulars, we may instance the sub-section dealing with "mechanical generators of electrical energy," which takes up 20 pages, and is practically nothing more than a collection of catalogue extracts. Had a dozen leading makes been selected, and had the principal data connected with them been reduced to a common denominator and arranged in a manner admitting of rapid rough comparison, a potential purchaser, in a quandary as to the particular pattern best suited to his purpose, would have been given something to the point.

Electricity. By J. T. Sprague. Third Edition. 1892. (London: E. and F. N. Spon.)

In his preface to the third edition of this well-known work we learn that "one-third of the book is re-written; nothing of consequence has been omitted, but to make room for the new matter some of the less important illustrations have been set aside, and all unnecessary words cut down; but the work as a whole remains what it was, the expression of original thought and work, not a mere orthodox text-book."

These last few words express most clearly and comprehensively the position which this book ought to take. It cannot be recommended to beginners, but no student who has been well grounded in electrical science should omit to consult it, if only to obtain an excellent account of the history of the theories and applications of electricity. Among the useful practical features of Mr. Sprague's work the tables are perhaps the most important. He was the first to draw up a good table of the resistance and weight, &c., of copper wire, and though many

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others have since been calculated the smaller tables of conversions of constants are nowhere given in a more useful form.

While Mr. Sprague was the first to graduate a galvanometer to read the current directly, using, for want of a better, a unit of his own—the chemic—the pages devoted to galvanometers are perhaps the least satisfactory. The chemic and the equivolt still linger in the text and in the glossary.

The chapters on electro-metallurgy are among the most valuable. In the preceding chapter on electrolysis we find that Mr. Robertson's research on the presence of peroxide of hydrogen in secondary batteries is mentioned, and other parts of the book are equally well up to date, the experiments of Siemens and Swinburne at the Crystal Palace being described.

The most original portion of this thoroughly original book is the part devoted to Mr. Sprague's theory of current. His arguments were fully set forth in a discussion between himself and Prof. S. P. Thompson, which appeared in Vols. XXVI. and XXVII. of *The Electrician*. The summing-up of this discussion seems to show that Mr. Sprague prefers to explain phenomena of induction by "conditions of inductance and magnetance" rather than "a product of energy seeking dissipation in the 'medium.'" If he went no farther than this we should be disposed for the present to agree with him, since the magnetic explanation of electro-dynamics requires the fewest assumptions; but Mr. Sprague pushes the hydraulic analogy rather farther than that point which is commonly called orthodox.

A Dictionary of Electrical Words, Terms, and Phrases. By E. J. Houston. Second Edition re-written and greatly enlarged. (W. J. Johnston and Co., New York, and "The Electrician" Printing and Publishing Company, London.)

The fact that a second edition of this Dictionary has been called for shows that there is more use for it than would at first sight appear. Lawyers, for example, who have to "get up" an electrical case might find some reliable definitions and explanations which they could use with confidence without necessarily understanding them, but for students and persons engaged in electrical work it is not only better but necessary that they should understand the terms they have to use, unless they are of extraordinary rarity, such as "Isochasmen curves," which are drawn between zones on the earth's surface, having equal frequency of auroral discharges. The intelligent outsider may find this Dictionary of use if he desires to plunge into electrical literature, and it will be of value to those who are engaged in some allied science such as chemistry. The arrangement of the work might be considerably improved. Cross references are carried to a ridiculous extent, following each other continuously in some cases for several columns. To find the meaning of a "long shunt" we look in vain under "long," "shunt," "compound," or even "dynamo," but discover it under "machine." If the Dictionary were reduced by the omission of hundreds of unnecessary cross-references and such entries as the following, "Machine, Dynamo-Electric, to short circuit, a ..... To put a dynamo-electric machine on a comparatively small electric resistance," its usefulness would be increased. Magnetism is overdone; attempts are made to give digests of various theories. It is not the practice in American publications to place the illustrations in immediate proximity with the descriptive text, but this sensible plan has been followed, as a rule, in this Dictionary, and is to be highly commended. We notice, however, that an illustration of the Elihu Thomson meter is given under "Meter, Watt-," with a description of a dynamometer wattmeter.

MAGNETIC VISCOSITY.

BY J. HOPKINSON, F.R.S., AND B. HOPKINSON.

The experiments herein described were made in the Siemens Laboratory at King's College. The object was to ascertain whether the cyclical change in the magnetic induction in iron due to a given cyclical change in the magnetising force is independent of the speed at which the change is effected, that is, whether any sign of "magnetic viscosity" or "magnetic lag" can be observed when the rate of change is such as is found in transformers. The question is one of much practical interest, and has been much discussed, amongst others, by Prof. Ewing at the recent meeting of the British Association. Prof. Ewing has devised apparatus adapted to deal with this matter as well as for drawing curves of magnetisation.

We have experimented on two materials. One was soft iron and the other a hard steel containing about 0·6 per cent. of carbon. Both samples were supplied by Messrs. Richard Johnson.

It had been found, in experiments on ordinary transformers, that the local currents in the iron made it impossible to form a correct estimate of the magnetising force. The effect of such local currents can, of course, be diminished by using finer wire or plates and better insulation. Our material was in the form of wire $\frac{1}{100}$in. diameter, and the wire was varnished with shellac to insure insulation. It was wound into a ring having a sectional area of 1·04 sq. cm. in the case of soft iron, and 1·08 sq. cm. in the case of hard steel, and about 9cms. in diameter. The ring was wound with about 200 turns of copper wire, and with a fine wire for use with the ballistic galvanometer. An inspection of the curves showing the results will satisfy the reader that the effects of local currents were negligible.

For determining the points on the closed curve of magnetisation, given by rapid reversals of the current in the coil, the ring was connected in series with a non-inductive resistance to the poles of an alternate-current generator or a transformer excited by the generator, thus:—

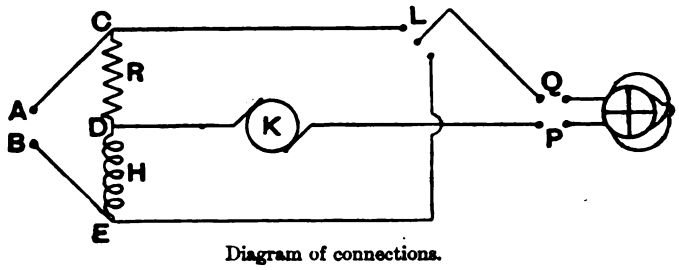

Diagram of connections.

in which A B are the poles of the transformer or generator, C D the terminals of the non-inductive resistance R, H the coil surrounding the ring, P and Q the studs of a reversing key connected to the quadrant of a Thomson quadrant electrometer, L a key by means of which Q could be connected with C or E at will, and K a revolving contact maker through which P was connected to D. A condenser was connected to P and Q in order to steady the electrometer readings. The contact maker K was bolted on to the axle of the generator. It consists of a circular disc of ebonite, about 13in. in diameter, having a small slip of copper about $\frac{1}{16}$in. wide let into its circumference. A small steel brush presses on the circumference and makes contact with the piece of copper once in every revolution. The position of the brush can be read off on a graduated circle, and thus contact can be made at any desired instant in the revolution, and that instant determined by means of the graduated circle. The quadrant electrometer thus gives the instantaneous value of the difference of potential between the points C and D, or the points D and E, according to the direction of the key L. The frequency was in all cases, except one, 125 complete periods per second. From observations of the values of the potential difference between C and D at different times in the period, a curve (A) was plotted giving the current or magnetising force in terms of the time; a similar curve (B) was plotted for the electromotive force between D and E. The curve (B) corrected by subtracting the electromotive force due to the resistance of the coil H gives the potential or time rate of variation of the induction in terms of the time. Hence, the area of B up to any point plus a constant, is proportional to the induction corresponding to that point. This is shown in curve C, which is the integral of B. A fourth curve D was then plotted in which the abscissa of any point is proportional to the magnetising force at any time (got from curve A) and the ordinate is proportional to the induction at the same time (got from curve C).

It is obvious that at the point where B cuts the axis the induction is a maximum; hence, if there were no "magnetic

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lag" and no currents in the iron, this point should occur at the same time as that at which the current is a maximum. In the curves referred to this is seen to be nearly the case.

The slow cycles were obtained from the ballistic galvanometer, by observing the throw due to a known sudden change in the magnetic force. Care was taken always to take the material through the same cycle. The points got by the slow method are in each case shown in absolute measure on the same

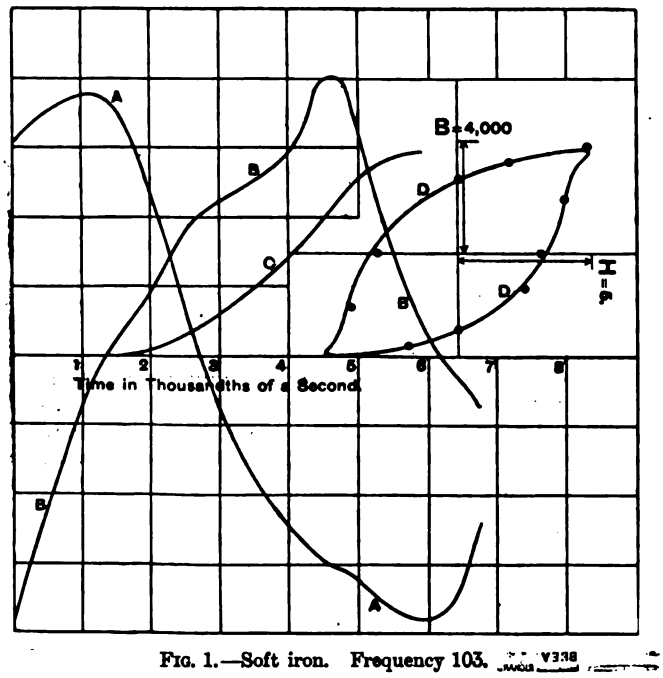

FIG. 1.—Soft iron. Frequency 103.

scale as that to which the quick curves are drawn, and are indicated by black dots; they are hardly numerous enough to draw a curve with certainty, but are ample to exhibit the identity of or the character of the difference, if any, between the curves, as determined by the two methods.

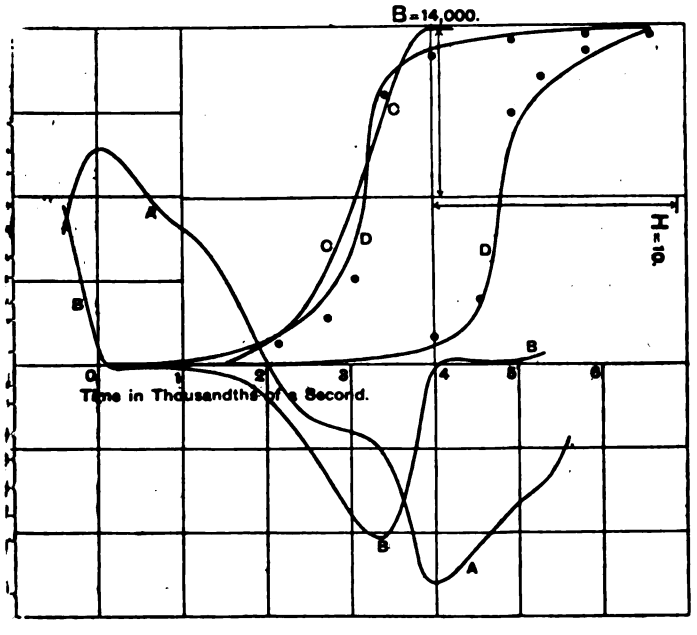

FIG. 2.—Soft iron.

Figs. 1 and 2 show the results of experiments on soft iron, Figs. 3, 4, and 5 were obtained from the hard steel. In all these the agreement between the slow and rapid cycles is fairly close. Fig. 6 is interesting, as showing the large effect of local currents. It was obtained from the same sample of steel wire as Figs. 3, 4, and 5, but the wire was *not* varnished. It will be seen that the maximum induction lags behind the maximum magnetising force about one-sixth of a complete period, and also that the maximum induction attained is but 10,000 as against 17,200 obtained from the same (apparent) magnetising force by the slow method.

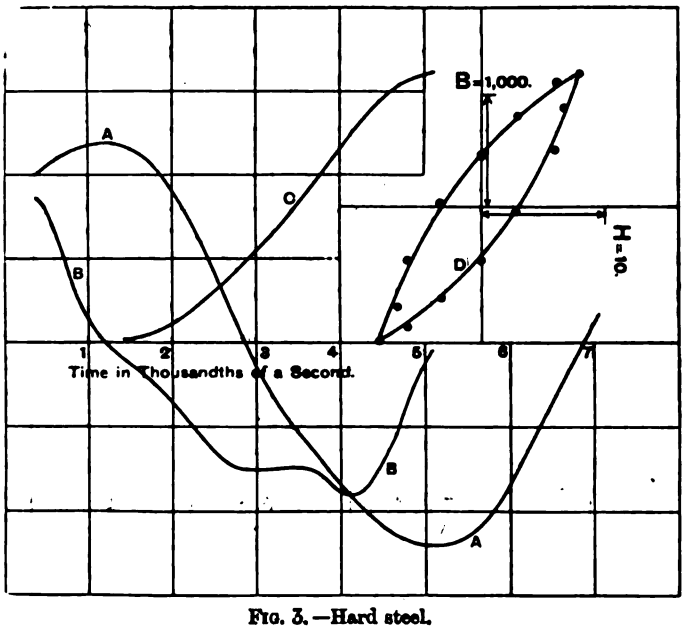

FIG. 3.—Hard steel.

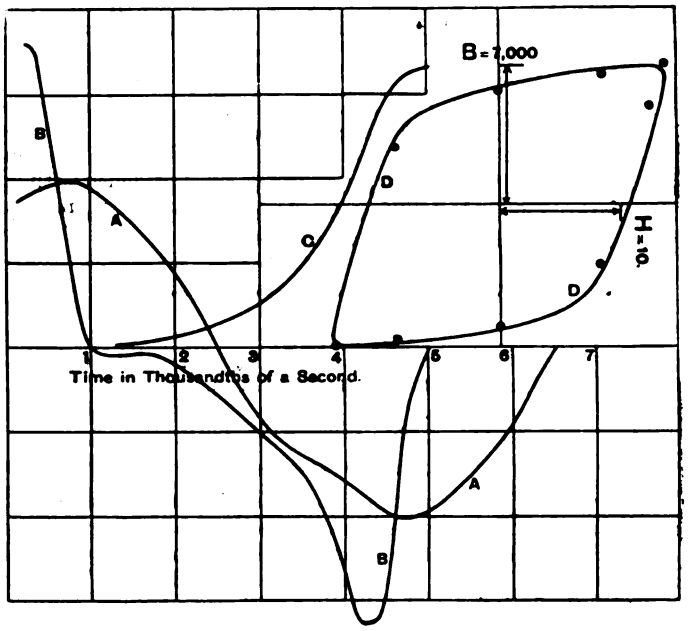

FIG. 4.—Hard steel.

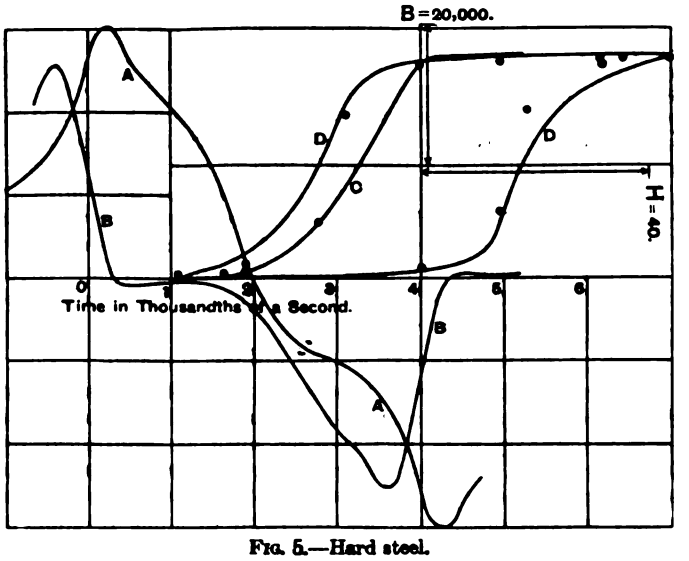

FIG. 5.—Hard steel.

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Hence the general result is, that up to the frequency tried, *i.e.*, about 125 per second, there is no sign of magnetic viscosity; the magnetic cycle is unaffected by the frequency so far as the maximum induction for a given magnetising force is concerned; but that there is a sensible difference between the curve as determined by the two methods, most apparent in that part of the curve preceding the maximum induction. This difference

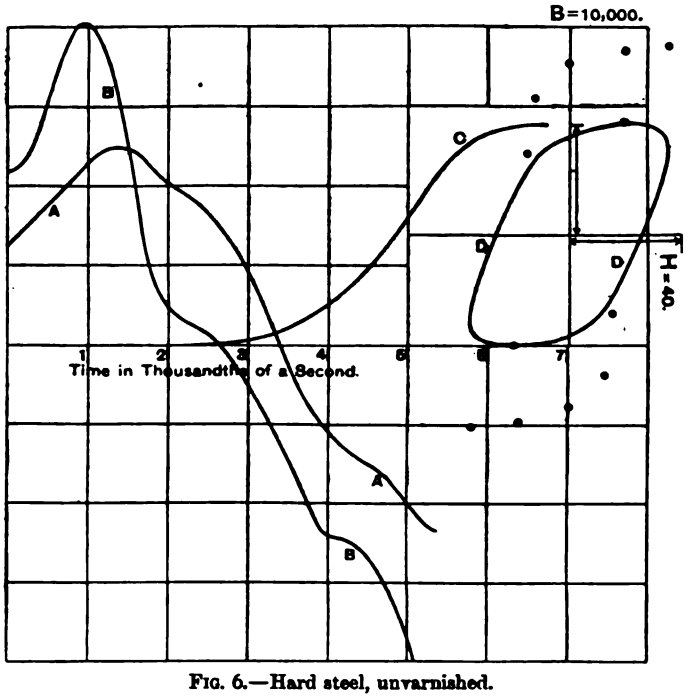

FIG. 6.—Hard steel, unvarnished.

is well shown in Fig. 5. We have not yet fully investigated this feature; possibly it arises from something peculiar to experiments with the ballistic galvanometer.

GEARING.

BY E. TREMLETT CARTER,

(Continued from page 455.)

Friction Pulleys.

The main objection to the two kinds of gearing which have now been described—belts and ropes—is that they require considerable, and in some cases impossible, amounts of floor space, owing to the long centre distances which must be given between the driving and following pulleys. A more compact form of gear is found in the friction pulley, in which the two pulleys, one of which is driving the other, are placed with their rims in direct contact.

When two pulleys are pressed together at their rims and one of them is set in motion, the other will be turned in a contrary direction with such a speed that the surfaces will roll over one another at the point of contact, provided the resistance to turning of the driven pulley is not greater than the friction at their contact surfaces. Power will thus be transmitted directly from the one pulley to the other. If P is the total pressure between the surfaces of contact measured normally to those surfaces, and μ is the coefficient of friction between the materials of which the surfaces are composed, then, since there is no fluid lubricant to modify the ordinary laws of solid friction, it is evident that:—

$P\mu$ = maximum resistance without slipping.

As it would obviously be unwise to allow the resistance of the driven pulley to become so large as actually to reach this limit in ordinary work, this product must be multiplied by some constant k (less than unity) depending on the materials of the pulley surfaces and on the conditions of working. In steady working, with materials not liable to suffer if slipping occurs at intervals, k may be taken at 0·9; whereas if sudden variations either in the driving effort or in the resistance are likely to occur, a lower figure must be taken. The power transmitted is therefore:—

$$\text{H.P.} = \frac{k.P.\mu.V}{33000} = \frac{\eta.k.\mu.P.D.N}{33000},$$

where D is the diameter of the driving pulley and N its speed in revolutions per minute.

It is found in practice that it is best to have one pulley surface of ordinary turned cast iron, covering the other with some material to increase the friction. Wood, millboard, gutta-percha and paper pulp are among the most common materials used for this purpose. It is found that the gearing wears best if the layer of extra material is put on the face of the driving pulley. This is most frequently the larger of the two pulleys. The following table gives the coefficients of friction, and the working pressure per inch width of pulley, for some of the most common materials working on turned cast-iron:—

Material.	μ.	lbs. per inch width.
Cast Iron	0·15 to 0·2	300
Wood	0·25 to 0·4	90 to 120
Millboard	0·20	100
Leather	0·3 to 0·4	100
Guttapercha	0·6	50 to 80

Wood is by far the most commonly used of these materials; oak, maple, beech and pine being the most serviceable. The crushing strength of timber is greatest if the fibres are set normally to the pulley face, but the coefficient of friction is least. It is usual to set the fibres parallel to the direction of motion of the rim—*i.e.*, tangentially along the rim.

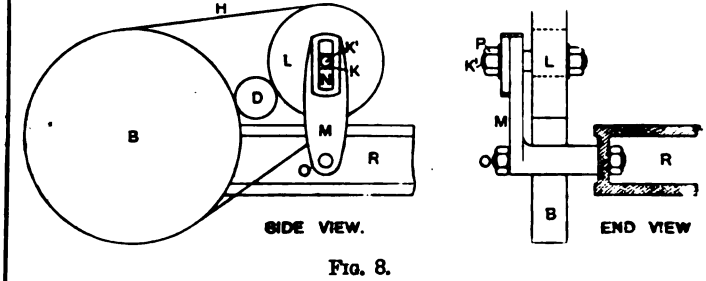

FIG. 8.

Owing to the very limited amount of pressure which can be put on the contact services of the pulleys, friction pulley gear will only transmit large amounts of power if the velocity of the rims is very high. It is clear that centrifugal force does not operate to reduce the power transmitted, as it does in flexible belt or rope gear, so that there is not the same objection to high peripheral speeds. It must not be forgotten, however, that, although this force does not reduce the friction, it sets up injurious stresses on the material of the pulley rims, both on the metal itself and on the band of wood or other substance covering it. At high speeds there is a liability on the part of the covering to strip off the pulley, and on the part of the pulley rim to burst. It is not advisable to use paper or millboard for velocities exceeding 5,000 feet per minute, and the usual practice with these rims is nearer 3,000 feet per minute; while, for wood blocks securely fastened into the pulley face, the speed should not exceed 6,000 feet per minute with cast-iron pulleys, and 7,000 with steel pulleys. These high velocities are more commonly met with in America than in England, steel pulleys being conspicuous by their absence in engineering on this side of the Atlantic.

An ingenious combination of friction pulleys and belt gear, the invention of Mr. Killingworth Hedges, is shown in Fig. 8. This consists of a driving pulley B, and a machine pulley D in frictional contact with it; while on the further side of D there is a larger idle pulley L, this being in frictional contact with D and in belt connection with B. Thus, when B turns, part of the power is transmitted directly to D by friction, and the rest through the belt to L, and then, by friction, to the other side of D; the side thrust of B on D being balanced by the opposite thrust of L on D. The centres are not exactly in line, and slackness in the belt is compensated by bringing them more nearly into line, thus increasing the centre distance between B

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and L. This is done in the following ingenious manner:—The idle pulley L turns on a spindle K′ fixed to a block K. This block is capable of being raised or lowered in a slot N, by means of a set screw P, and by its position determines the degree of tightness of the belt. The slot N is cut in a lever M, which is freely pivoted at O.

Countershafting.

When a single engine is required to drive two or more machines, or whenever the velocity ratio between the engine and machine pulleys is too high for a single belt to be placed on both, some intermediate line of shafting, called countershafting, must be employed. The power is supplied to this shafting at a pulley, placed in connection with the engine by means of a belt or set of ropes, and is transmitted to other pulleys keyed on the shaft and driving the machine gearing. The shaft transmits the power by virtue of a torque which is set up, and the magnitude of this torque varies directly with the power and inversely with the speed. If T = the torque in inch pounds horse-power, the horse-power passing any section of the shaft, and N the revolutions per minute of the shaft, then—

$$T = \frac{63000 \text{ H.P.}}{N},$$

at this section. It will be observed that the torque is not necessarily the same at all sections; and that by a different arrangement of the machines it may be altered. Thus, if the power is supplied at the middle of the line of counter-shafting and distributed equally on either side, the torque will be only half that which would occur if all the machines were placed on the same side of the driving pulley. A smaller and lighter shaft, and one that will waste less power, will therefore be sufficient if the former arrangement is adopted instead of the latter. Again, by placing the heavy machines near the engine pulley on the counter-shaft, and the smaller machines further away, the efficiency of transmission is increased, since the power will have on the average to traverse less length of shafting.

The effect of torque on a shaft is to set up a shearing stress on every part of the section. If the section is circular, the stress on any part varies directly as its distance from the centre of the circle; so that the outer portion transmits much more power than the metal near the centre. The torque which any portion of the section will resist is equal to the product of the stress on that portion multiplied by its distance from the centre or axis of the shaft; and the total torsional resistance of the whole section is evidently the surface integral of this product over every portion of it. Thus, the resisting and power transmitting value of any portion of the material varies as the *square* of its distance from the axis of motion of the shaft. In hollow shafting only the more useful portions of the section are utilised, the central portions containing no metal. For the same weight of material a much stronger shaft is obtained; *i.e.*, the hollow shaft which will transmit the same power as a solid one, is, other things being equal, a lighter one. The extra expense of forging or casting a hollow shaft, however, renders its use prohibitive except for very large sizes. Ordinary countershaft is usually of solid circular section, and is made of mild steel or wrought iron. Cast iron was formerly used for this purpose, but with the introduction of higher speeds, and the consequent rapid variation of stress to which shafting was subjected, this brittle and unreliable material had to be abandoned. The maximum safe working stress to which these materials may be subjected in countershafting running from friction gearing is 13,000lb. per square inch for mild steel, and 9,000lb. per square inch for wrought iron. Toughness, to the extent of about 25 per cent. elongation before fracture, is a desirable quality in these materials.

Besides the necessary precaution of keeping the maximum stress on the shaft below the given limits, there is another important consideration. Under torsion a shaft is twisted through a certain angle, *i.e.*, the driving end is always a little angle ahead of the machine end. If this angle is allowed to exceed a certain figure, the shaft runs irregularly and vibrations take place. This is owing to the shaft catching, as it were, in the bearings, then slipping and catching again. The shaft gets twisted up till the torque is sufficient to turn it in the bearings, the friction diminishes directly motion takes place, the shaft consequently runs a little faster than the normal speed and slackens down the torque till it catches again, when the operation is repeated. The rapid repetition of this vagary causes unsteady and noisy driving, and can only be obviated by making the shaft stiff enough to limit the twist to a very small angle. In machine spindles and countershafts the amount of angular twist is about 1deg. for each length of shaft equal to 20 diameters. If a greater rate of twisting is permitted the driving is liable to be unsteady.

In Fig. 9, let r_1 represent any radius of the shaft which is twisted away from another radius r_2, with which it was formerly parallel, by the effect of the torque; and let $\frac{d\theta}{dl}$ represent the angular shear between them. Let E be the modulus of elasticity of the material, under shearing stress; and f the stress at the outer edge of the circle. The strain at the outer edge is—

$$\text{Strain} = r \cdot \frac{d\theta}{dl}.$$

And this bears a constant ratio to the stress, within the elastic limit; therefore,

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{f}{r \cdot \frac{d\theta}{dl}}$$

But, since the rate of angular twist is the same throughout the whole length of shaft,

$$\frac{d\theta}{dl} = \frac{\theta}{l}$$

From which

$$\theta = \frac{f \cdot l}{E \cdot r} \text{ in radians.}$$

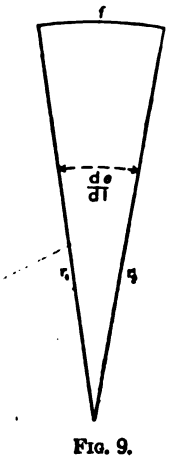

FIG. 9.

This shows that if we keep f within the safe working limits for all lengths and diameters of shafting, we must allow the angle of twist to vary directly as the length and inversely as the diameter. In practice,

$$\theta = \frac{l}{40 \cdot r} \text{ degrees,}$$

where l and r are measured in inches.

The amount of torque which is required to produce any given angular twist in a circular shaft varies directly with the angle and with the fourth power of the diameter, and inversely with the length. For mild steel,

$$T = \frac{34{,}300\, d^4 \theta}{360\, l} \text{ lb.-ft.} = \frac{34{,}300\, d^4 \theta}{30\, l} \text{ in.-lb.}$$

For wrought iron,

$$T = \frac{16{,}600\, d^4 \theta}{360\, l} \text{ lb.-ft.} = \frac{16{,}600\, d^4 \theta}{30\, l} \text{ in.-lb.}$$

Substituting the value of θ,

$$T = 686\, d^3 \text{ in.-lb. (mild steel),}$$
$$T = 332\, d^3 \text{ in.-lb. (wrought iron).}$$

Where, for convenience of working, d is taken in inches and l in feet. Equating this to the expression for torque in terms

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of the power transmitted, which we deduced at the commencement of this article, we get—

$$683\ d^3 = \frac{63{,}000\ \text{H.P.}}{N},$$

or,
$$d = \sqrt[3]{\frac{93{\cdot}7\ \text{H.P.}}{N}}\ \text{(mild steel)},$$

and,
$$d = \sqrt[3]{\frac{190\ \text{H.P.}}{N}}\ \text{(wrought iron)}.$$

The margin that is allowed in the above rules for designing countershaft is ample; and no fear need be entertained that the material will be overstrained, provided only that the pulleys and bearing supports are properly arranged. Countershafting is subjected to bending action, in addition to the torsion due to the power transmitted. This bending causes a tensile stress on the material on the lower side of the shaft, and a compressive stress on the upper side, except in the case of overhung shafts, when the conditions are reversed. As the shaft rotates, the various portions of it are subjected to rapidly alternating stresses, each part coming under tension and then under compression in every revolution. This lively load is severe in its action, rendering toughness a necessary quality of the material, and causing deterioration in even the toughest and best qualities of iron and steel. The intensity of this stress depends on the rapidity with which it reverses, *i.e.*, on the speed of the shaft, and on the arrangement of the pulleys. By placing

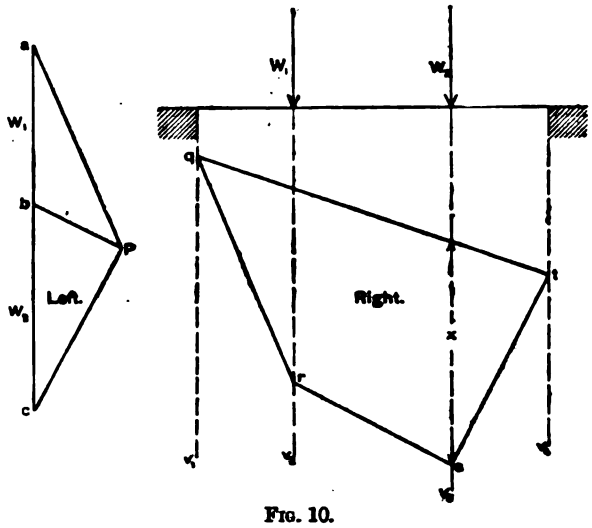

Fig. 10.

the heavy pulleys, and those on which the tensions of the belts is greatest, near the bearings the bending moment is made much smaller than if those pulleys are placed in the middle of a long span of shafting. Again, by reducing the distance between any two bearings, the maximum bending action on the section of shafting between them is reduced. It is the usual practice in fixing a line of countershafting to so space the bearings, and so arrange the pulleys, that the maximum bending moment shall not exceed the torsional moment; but the limit of working stress in the above formulæ will permit of a bending action equal to twice the torsion, in cases where it is impracticable to further reduce the bending.

The best method of estimating the distribution of bending action along a shaft is by means of Culmann's diagram. A scale drawing (Fig. 10, right) of the length of shafting between two supports, with the points of application of the several loads, is drawn to a scale of A inches to the foot; verticals V_1, V_2, V_3, V_4, &c., being drawn through the points of application, including the reactions at the supports. A stress diagram (Fig. 10, left) is drawn to the scale of B inches to the ton, commencing at the top with the left hand load and drawing lines *a b*, *b c*, &c., in the direction and order of the loads. A point, P, at a normal distance, C inches from the stress line *a c*, is joined to the points *a*, *b*, and *c*. Parallel to these, slanting lines are drawn in order, commencing with *aP* from the verticals V_1 V_2 V_3 and V_4, forming the sides of the polygon *qr*, *rs*, *st*; and the closing line of the polygon *tq* is then drawn. The lengths of vertical line included between the top and bottom of the polygon are proportional to the bending moments at the points on the beam vertically above. Thus, the maximum bending moment is at W_2, and is represented by the distance *x* included in the polygon. To find the bending moment in tons feet, the distance *x* in inches must be multiplied by the product *BC* and divided by the scale *A*, to correct for the reductions in scales. In this example the weight of the shaft has been neglected, but it is not usually safe to neglect it. A sufficiently near approximation, in the case of countershafting, can be made if the weight of the shaft is considered as a weight of half its value concentrated at the centre of the span; it may then be introduced into Culmann's diagram as a single additional load.

An examination of the diagram of bending moments will enable one to see that there is little or no bending action on the material of the shaft included in the bearings, while under the pulleys it is usually large. It is possible, therefore, to cut away the shaft to a smaller diameter at the bearings, thus reducing the loss of power on account of friction without seriously reducing the strength of the shaft. It is not possible to cut even a key-seat in the shaft under the pulleys without taking away active and necessary material; so that if the pulleys are to be keyed to the shaft by means of sunk keys, as is usually the case, account must be taken of this in selecting the diameter of the shaft, or a boss must be made on the shaft at the place where the pulley is to be keyed. The latter practice is adopted in the case of shafts of large diameter, as a shaft uniformly of the diameter under the pulleys would be too heavy and wasteful of power at the bearings; but with smaller sizes of countershaft, transmitting small amounts of power, it does not pay either to make bosses under the pulleys or to turn down the shaft at the journals. Some generating stations which pass considerable amounts of power through countershafting, such as at Taunton or at the Crystal Palace, use such large diameters of shafting that it pays to prepare it in the manner described; but, as a rule, countershafting is not used at all in large generating stations.

Countershaft Bearings.

There are several points to be observed by an electrical engineer in designing and setting up the bearings for a line of countershaft, and upon which the efficiency and regularity of running will greatly depend. The *bête noir* is undoubtedly the overheating and seizing of bearings, but there are minor troubles which can readily be avoided by judicious design and careful arrangement of the bearings. Rules are sometimes given to enable one to arrive at the proper distance between bearings; but all such rules which do not take into account the particular conditions of the gearing are misleading and dangerous. While 10ft. would be quite near enough in some cases, it would be much too long in others, even for the same size of shafting. The writer can think of no better rule than that which was adopted in the design of the shaft, viz., to keep the bending moment down to the value of the torque or thereabout. It must be remembered that with friction clutches in the shaft the bending action on the shaft when the clutch is out of gear is nearly four times as great as when it is locked and transmitting power; so that it will generally be found necessary to place the clutch close to one bearing if it is of small size, or between two bearings if it is of large size.

The number and position of the bearings having been determined, it will next be necessary to decide on the amount of bearing surface which each should have. To do this it is necessary to know the load on each bearing, which may be calculated or scaled off from Culmann's diagram of bending moments. The amount of surface for the brasses should be chosen with a view to getting only a limited amount of load on each square inch of surface. According to the so-called "laws" of friction, the friction ought to be independent of the amount of surface in contact; but, as a matter of fact, it is largely dependent upon it. A high-pressure squeezes out the lubricant from between the surfaces, and increases the coefficient of friction; while a low pressure renders a long bearing necessary, and increases the friction if the bearings are not in strict alignment. The amount of pressure which can safely be put on each unit of countershaft bearing surface is found to depend on

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the viscosity of the lubrication and on the velocity of the rim of the shaft in the brasses. With high speeds, and with light oils, a small pressure only is allowable; while with heavy oils and slow-speed shafts a larger pressure is permitted. Since heavy oils are always used for slow speeds, and lighter oils for quick-running shafts, it follows that the amount of pressure which can be put on each unit of bearing surface depends only on the speed. The average pressure is 200lb. per square inch of axial section of the shaft included in the bearing; while for high-speed shafts the figure may fall to 100lb., and for low-speed shafts it may exceed 300lb. These figures relate only to countershafting. Bearing surface is measured as the product of the diameter of the journal into the length of shaft in contact with the brasses; or, as the axial section of the shaft. Therefore,

$$d \cdot l = \frac{P}{200},$$

where d is the diameter of the journal and l its length, in inches; and P is the load on the bearing in pounds. From this the *minimum* length of the bearing can be calculated. It may occur, however, that this length is small compared to the diameter of the shaft, owing to the load on that particular bearing being small; it will then be necessary to take a longer bearing. Countershaft bearings are usually from $1\frac{1}{4}$ to $1\frac{1}{2}$ times the diameter of the shaft in length.

The power wasted at the bearings depends on the size and distance apart of the pulleys. With all belts off, light mill-shafting wastes about 1 H.P. per 100ft. run; but crowded, heavy shafting, such as is used in electric light work, would probably waste between 5 and 10 H.P. per 100ft. under the same conditions. With belts on, the gearing should absorb not more than from 10 to 15 per cent. of the power supplied from the engine.

(To be continued.)

THE ELECTRIC TRAMWAY AT HALLE.

The Halle electric tramway is on the single overhead wire system. There are some steep hills on the route, which would necessitate the use of a third horse, if animal traction were used, but these are surmounted without difficulty by the electric cars. The power station, a general view of which is given in Fig. 1, contains three Steinmüller water-tube boilers having 1,520 square feet of heating surface each, and a grate area of 30 square feet, and are built for a pressure of 150lb. per square inch. Two of these boilers suffice for ordinary work, so that the third is kept as a reserve. Water is obtained from the town mains, but as it contains a large amount of alkaline matter it is passed through a Humboldt purifier before being allowed to enter the boilers.

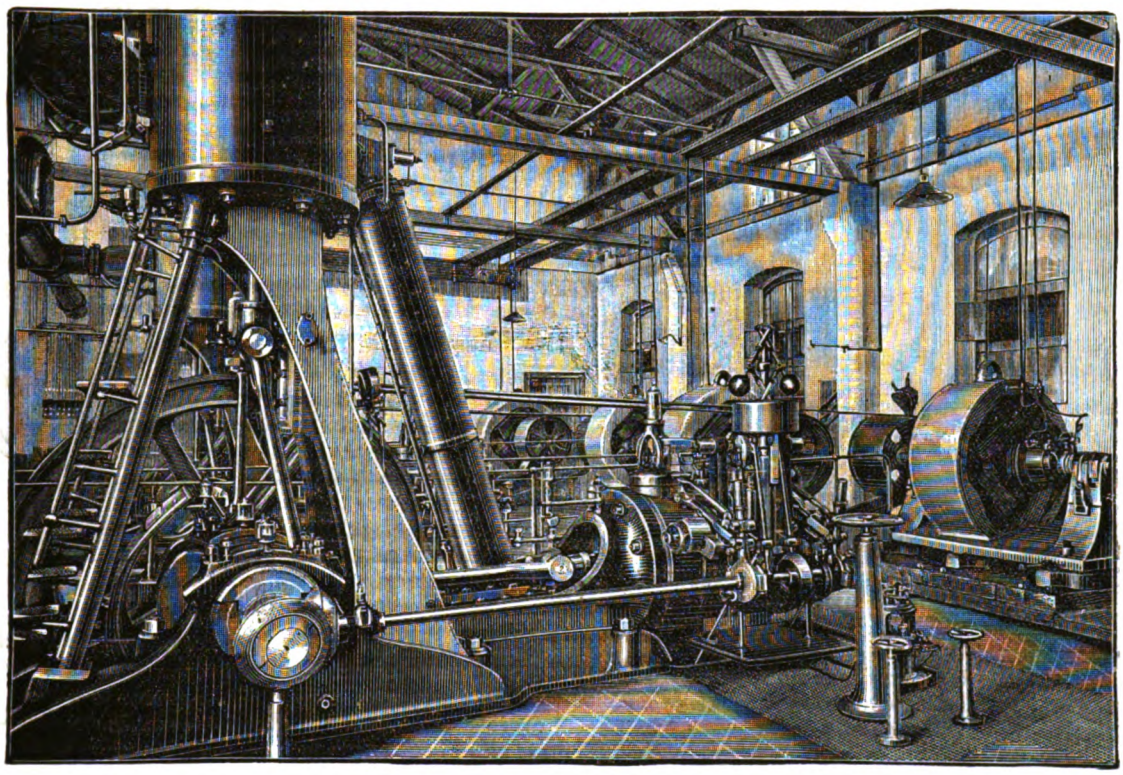

Fig. 1.

These boilers supply steam to two large engines built by the Gorlitz Machine Building Company. These are combined horizontal and vertical non-condensing engines. The horizontal high-pressure cylinder is 13in. diameter, 22in. stroke, and is furnished with Collman's valve gear. The vertical low-pressure cylinder is 21in. diameter and 22in. stroke. Each engine at the normal speed of 180 revolutions, with a pressure of 120lb., gives 125 effective horse-power, which can be increased to a maximum of 200 H.P. when the boiler pressure is raised to 150lb., so that either engine alone is capable of supplying the whole of the power needed for working the line. The valve gear works so satisfactorily that the same dynamo is used for lighting purposes whilst supplying power, and in spite of the high speed the engine runs quite steadily and without vibration.

The two engines drive, by means of belting, four dynamos, which, with all the rest of the electrical plant, were supplied by the Allgemeine Elektricitäts Gesellschaft. These machines are shunt wound, and give 500 volts 120 amperes at 520 revolutions. The poles of the dynamos are connected to two bars on the switchboard, one of which communicates by means of an insulated conductor with the overhead wire, whilst the other is joined to a naked cable leading to the running rails, and containing an ammeter reading to 800 amperes, and a main fuse. The main switch is on the overhead line lead, but each machine can be switched on or off the bars by a double pole arrangement. The regulation of the voltage is effected in the ordinary manner by an adjustable resistance in the shunt winding.

The arrangement of the overhead conductor is on a system introduced by the Allgemeine Elektricitäts Gesellschaft which is a modification of that of Sprague. It consists of two parts, the conductor proper and the working line. The former is insu-

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lated and is partly above and partly below ground; in the former case it is suspended from poles, in the latter it is simply an armoured lead cable laid in the ground. In Halle it has a section varying from 50 to 95 sq. mm.

The working line is connected by cross wires at intervals to this conductor. In the present case it consists of a silicon bronze wire 6mm. ($\frac{3}{16}$in.) in diameter (about No. 4 B.W.G.). It is so stretched as never to come lower than 18ft. from the ground and is suspended in the narrow streets by light steel wires running from house to house and fixed to insulators, and in broader places by wrought iron poles. The iron poles have a cast-iron top in which a block of wood boiled in paraffin is fixed by means of sulphur, giving the line a double insulation. In some places two rows of poles are used with suspension wires passing between them.

A similar arrangement of suspension wires has to be adopted wherever curves, turn-outs, &c., occur throughout the track. Due provision has been made for the expansion and contraction caused by a range of temperature amounting to 130°F. The running rails, which form the return conductor, are bonded at the fishplates with a metal strip in the usual manner, and being of a heavy section, form a return of very low resistance.—

The line comprises three sections, having a total length of nearly five miles. The gauge is one metre, and the radius of the sharpest curve from 40 to 45ft. This necessitated a very short wheel base (about 5ft.). The current is collected from the working conductor by a trolley running on its under side, and supported by a steel arm pressed upwards by a spring, and carried by a flexible joint from the car roof. The motors, two of which are carried on each truck, are built by the Allgemeine Elektricitäts Gesellschaft, series wound for 500 volts at 1,150 revolutions. The carbon brushes require no adjustment when the direction of rotation is reversed. The arrangement of truck, including the method of suspending the motors, is that adopted in the United States by Sprague, whose German patents are owned by this Company. The necessary reduction in speed required to make the cars run at six miles per hour is effected through double-spur gearing, the wheels being of iron, and the pinions of aluminium bronze, with machine-cut teeth, and run in oil baths, being completely shut in by dust-proof boxes. A general view of the motor-frame is given in Fig. 2. Should either of the motors become defective it can be cut out of the circuit, and the car be worked by the remaining motor. Speed regulation is effected by changing the field windings, so as to avoid the use of wasteful resistances. The switch controlling this is actuated by an ordinary lever handle.

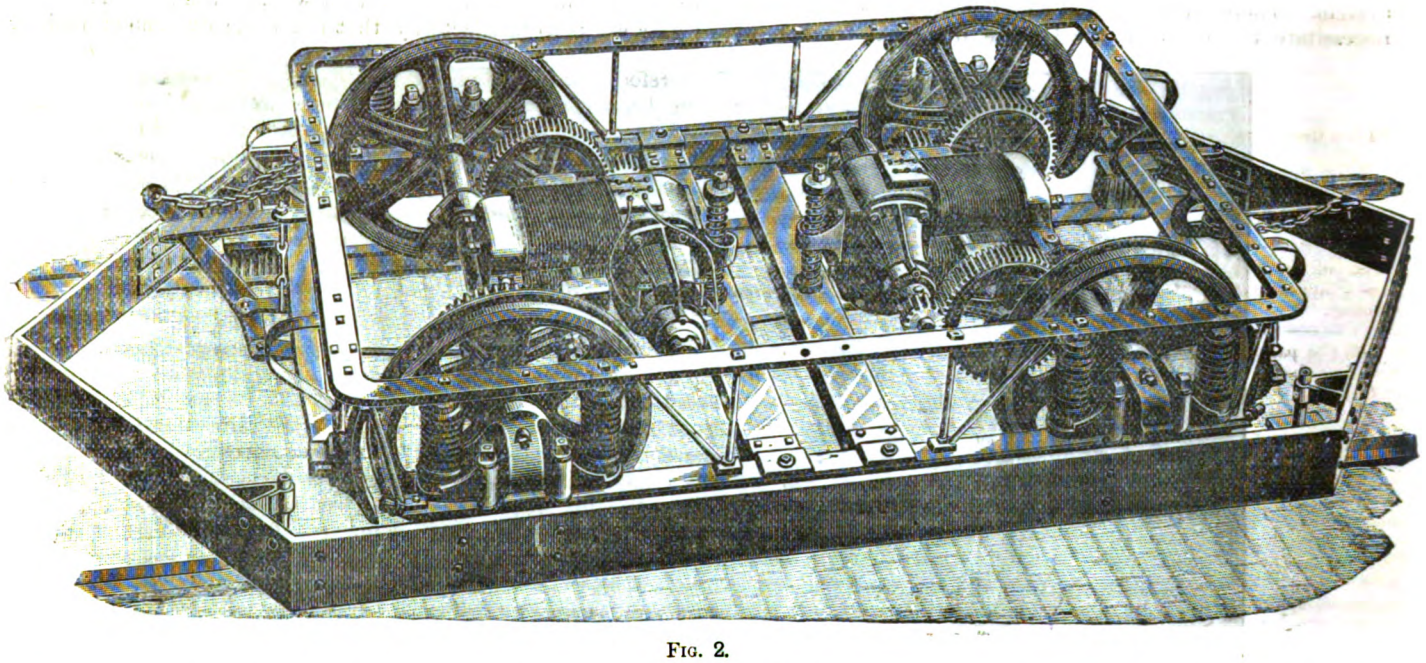

FIG. 2.

The rolling stock consists of 25 motor cars, and the same number of dummy cars, which at times of excessive traffic can be towed by the others. The introduction of electricity enabled a stud of 125 horses to be disposed of.

The cost of the entire equipment, including 25 electric cars, overhead conductors, buildings, &c., came to £30,000.

ON THE CLARK CELL.*

BY DR. KAHLE.

In connection with the Report of Mr. Glazebrook, I beg to call your attention to some researches I made, by order of the Physico-Technic Institute at Berlin, on Clark Cells. The time is too short for communicating my measuring methods and results in full extent; I can only give you a short summary of the chief points.

I used in my researches Lord Rayleigh's H form, the positive electrode being mercury once distilled, the negative an amalgam containing 90 parts of mercury and 10 parts of zinc. The last was filled in the vessel as a hot liquid, and solidified on the bottom. The paste, which covers the positive electrode, is made by grinding together mercurous sulphate, mercury, and a mixture of crystals and concentrated solution of zinc sulphate. No heat was used in preparing this paste. The mercurous sulphate was bought, and contained, according to chemical analysis, no foreign ingredients. The zinc sulphate was made basic by boiling with rods of metallic zinc; after cooling, the dissolved oxide of zinc precipitates, and with it the oxides of the metals more negative than zinc. For oxidising the ferrous sulphate, which is always present in commercial zinc sulphate, a small current was sent between two platinum electrodes through the boiling basic solution; the ferrous sulphate was changed by the generated oxygen into ferric oxide, and fell out. The H cells set up with these materials showed a great agreement in their E.M.F.'s; I never found a difference greater than $\frac{1}{10000}$th of a volt between the E.M.F. of any two of them.

The next point I studied was the influence of the impurities in the different materials composing the cell on the E.M.F., because on the one side it is well known that the smallest impurity of the mercury alters very distinctly the E.M.F., and

* Paper read before the British Association, in Section A, Edinburgh, August, 1892.

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on the other side the mercurous sulphate I bought never contained impurities of a remarkable amount, and different samples always had the same qualities; I only investigated, as the most important matter, the impurities of the zinc and its sulphate. It was found that the foreign ingredients of the zinc sulphate are of very little importance, and that only the presence of free acid in the above-described cleaning process, the result of boiling with metallic zinc, alters the E.M.F. in a considerable degree. Among the impurities of the zinc only those caused by metals more positive than zinc are of importance; the zinc may contain considerable quantities of the negative metals without any alteration of the E.M.F. I suppose the impurities of the zinc are of greater importance. If we use it in the form of rods amalgamated on the surface, it seems to be a great advantage to dissolve the zinc in mercury, using it then as a solid amalgam.

The following are the values I found by a great number of observations for the temperature coefficient of different forms of cells, measuring between 10deg. and 30deg. in rising and decreasing temperature. The figures here given are the mean values of some cells of the same form, treated in the same manner:—

Form of the cell.	Temperature coefficient.	Mean difference between calculated and observed values of E.M.F.	Mean difference between the E.M.F. of the different cells and that of the mean of several H cells used as standards.
		The unit being $\frac{1}{10000}$ of a volt.	
H cell set up in Lord Rayleigh's manner.	+0·000812 + 0·000013 (+ − 15)	12	+ 3
H cell, the paste covering both electrodes.	+0·000774 + 0·000020 (+ − 15)	12	+ 7
A new form for research purposes, the paste covering both electrodes.	+0·000791 + 0·000017 (+ − 15)	9	+ 9
The cell issued hitherto by the German Reichanstalt.	+0·0·0806 + 0·000006 (+ − 15)	30	− 29

The mean value of the temperature coefficient, therefore, would be

0·000796 + 0 000014 (+ − 15).

Lord Rayleigh has given the following values for the two different cells he investigated:

+0·000827 + 0·000018 (+ − 15)
+0·000740 + 0·000016 (+ − 15)

the mean being

+0·000783 + 0.000017 (+ − 15).

I suppose, for practical purposes, the value found by Lord Rayleigh and by me are identical.

The most important matter is to obtain the absolute term of the E.M.F. For the purpose I used a measuring arrangement similar to Lord Rayleigh's. The current, which produces on the terminals of a known resistance a pressure equal to that of the Clark cell, was obtained by the silver voltameter. It was found that the same current deposits the more silver the more oxide of silver is dissolved in the solution of the nitrate. I made a solution of nitrate crystals, and boiled a part of it a long time with oxide of silver; the deposit gained with this basic solution was about $\frac{5}{10000}$ths greater than that with the original solution. Therefore, using a certain number for the equivalent of silver, there will be a little uncertainty of some parts of 10,000 in measuring currents by the deposit of silver. Now, as first shown by Prof. Schuster, and also proved by me by a good deal of experimenting, the deposit, when the voltameter is in vacuo, is about four parts of 10,000 greater than in ordinary air. But the absolute value of the E.M.F. is not touched by this fact, because making the electrolysis in this manner one has certainly to take a greater figure for the equivalent, and therefore the ratio between the unit and the measured amount of current remains the same. The following figures are given by taking one ohm = 1·063 S.U., and by assuming that a current of one ampere strength deposits in an hour 4·0259 grammes; the last figure exceeds that given by the Board of Trade only by six parts of 100,000. I found by some 30 experiments the E.M.F. of the H cells, set up with clean materials in the above-described manner, as 1·4332 volts at 15deg., and am sure that, when using the same arrangement of the silver voltameter, this value will be right by five parts in 10,000 if the equivalent is certain to this extent. If I express the value given by Lord Rayleigh for the cells of the original Clark's form in this unit, it is 1·4346 volts at 15deg. Lord Rayleigh finds the E.M.F. of this H cell a few ten-thousandths of a volt greater than that of the old form. Therefore it would, perhaps, be 1·4350 volts at 15deg.

Recently Mr. Glazebrook has made a new determination, and finds in the above fixed units as E.M.F. of the original Clark cell, 1·4342 volts at 15deg. He has also compared H cells set up by me and now brought to England, and finds their E.M.F. by $\frac{4}{10000}$ths of a volt smaller than that of the original form Therefore, the E.M.F. of the H cell is 1·4338 volts at 15deg. This last value and that found by me are in good agreement. It is remarkable that the anodes and cathodes in my voltameters are much smaller than those in the English ones.

It may be mentioned here that the mean E.M.F. of four H cells set up in the same manner as before, but containing, in accord with Prof. Carhart's directions, a solution of sulphate of zinc, saturated at 0deg., was found as 1·442 volts at 15deg, using the same units as above.

It only remains to give some directions on the best form of Clark cells. I suppose it will be good to distinguish such cells which are to remain as standards in the laboratories and are used by their maker, and such as are to be used for practical purposes. These do not need to have the same degree of accuracy, but they must be able to be carried about. In the Board of Trade memorandum, the original Clark cell is adopted as the standard; but I suppose Lord Rayleigh's H form gives more accuracy and is easier to set up. In the old form, not all the parts of the zinc rod are in saturated solution, and therefore the value of the E.M.F. will be a little uncertain. Another disadvantage is that parts of the zinc rod may fall down in the mercury, and will so produce a considerable variation of the E.M.F. On the other hand, the electrodes of the H form are always in concentrated solution, and there is no possibility of parts of the negative electrode coming over to the positive one. I have set up about 60 H cells, and have found no difficulty, when using carefully cleaned materials, to keep the difference of the E.M F. of the single cells under a ten-thousandth of a volt.

To construct cells for practical purposes which will stand carriage, the most simple way is to separate the two electrodes by a porous wall. I can show here such a cell of a form constructed by Dr. Feupner, and issued hitherto by the German Reichanstalt. The positive electrode is an amalgamated platinum plate with the surrounding paste in a porous vessel of clay. The zinc rod forming the positive electrode is on the upper part protected by a glass tube; the lower part is blown rectangularly and covered with crystals of sulphate of zinc. The whole glass vessel is filled with a concentrated solution of this salt. The E.M.F. of such cells is about $\frac{3}{10000}$ths of a volt higher than that of the H cells. The agreement of different cells of this form is very sufficient for practical purposes; the difference between the E.M.F. is always smaller than $\frac{1}{10000}$th of a volt. The only disadvantage of this form is that its E.M.F. does not follow quickly the alterations of temperature; but I suppose one could improve that by diminishing the size of the cell.

We endeavoured in the Reichanstalt to make Lord Rayleigh's H form transportable on account of its good qualities, and to do this without introducing foreign substances as porous walls. The investigations in this direction are not yet finished, but I can

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show you here a cell which was constructed for this purpose and seems to be good. The positive electrode is formed by an amalgated platinum plate fixed on a wire of the same metal, which is melted in the bottom of one of the two tubes forming the vessel. The negative electrode is formed by the 10 per-centage zinc amalgam solidified on the bottom of the other tube, and also connected with a platinum wire melted in the glass. The whole vessel is filled with paste and closed by a glass stopper perforated by a thermometer, of which the bulb is within the vessel. Such a cell can be turned without any danger, and is suitable for transport. The E.M.F. is about $\frac{1}{10000}$th of a volt smaller than that of the H cells; the disagreement between the E.M.F.'s of different cells constructed in similar manner does not exceed $\frac{2}{10000}$ths of a volt. But before using such cells for practical purposes, they must be observed for a longer time till one is sure that their behaviour will not be altered by age.

These are the principal results gained during the last time in the Reichanstalt on this matter. Some of them will be already known here; but I hope to have given new proof that the Clark cell is a very accurate standard for E.M.F., and a good measuring instrument for practical purposes.

ELECTRIC HEATING AND SMELTING.*

BY STEPHEN H. EMMENS.

Newspaper readers have of late been frequently taught by their oracles that the day is close at hand when their houses will be warmed and their food cooked by electricity. And, even in technical circles, the phrase "electric smelting" is often used in a manner suggestive of some approaching industrial revolution. A plain statement of the facts and limits of the electrical heating problem in general may, therefore, prove useful.

One horse-power, exerted for one hour and completely converted into heat, is capable of raising the temperature of 645·85 kilogrammes of water by 1°C.=that is to say, 1 H.P.H=645,850 calories. One gramme of coal, if completely burnt, will yield heat sufficient to raise the temperature of 7½ kilogrammes of water by 1°C.—that is to say, the combustion of one gramme of coal generates 7,500 calories. There are 453·5926 grammes in 1lb. avoirdupois. Accordingly, 1lb. of coal will yield $7,500 \times 453{\cdot}5926 = 3,401,944$ calories, and 1 H.P. exerted for one hour is capable of the same heating effect as $\frac{645,850}{3,401,944} = 0{\cdot}1898$lb. of coal.

To produce by means of a steam engine one effective horse-power hour of electric energy, and to convert it into heat requires the combustion of about 4lb. of coal. Hence, to heat a room by means of steam-engine-generated electricity requires the consumption of $\frac{4}{0{\cdot}1898} = 21{\cdot}07$ *times as much coal as would be required by an ordinary stove.*

When I say that to produce, by means of a steam-engine, an effective horse-power of electric energy and to convert it into heat requires the combustion of about 4lb. of coal, I mean "to convert it into heat-output in a form available for heating buildings and the like, *i.e.*, into *radiated heat* emitted from the surface of an electric stove." Theoretically, if an electric current do no outside work it is *all* absorbed in heating the circuit, and in that case the efficiency of the apparatus (*i.e.*, the circuit) is the same as that of the dynamo; but where outside work is done by some apparatus included in the circuit the efficiency is the dynamo-fraction multiplied by the apparatus-fraction.

We know fairly well the apparatus fraction of an electric motor or transformer; but, as yet, no published data are available as to the proportion of current energy given off in the form of radiated heat from the surfaces of electric heaters. The only actual figures in my possession are those of a trial of two "Burton" and one "McTighe" electric stoves (car heaters) at Lincoln, Neb., last November. Mr. T. J. McTighe (of Barry and McTighe, electrical engineers), for whom I had conducted some preliminary experiments, sent me the figures. The trials were made by Mr. Francis Daniells, electrical engineer, and were carried out by enclosing the stove in a large box, and taking readings every ten minutes from a thermometer, the bulb of which was inside the box. It was considered that this showed the extent to which the internal atmosphere of the box was warmed by the action of the stove; but as the report is silent respecting any protective screen between the thermometer and the stove, I presume that the readings really showed the gain of heat on exchange.

* From the *Engineering and Mining Journal*.

The average result was as follows:—

	Rise per minute.	Electrical H.P.
McTighe	0·5°F.	0·605
Burton	0·4°F.	0·9045

The McTighe stove was composed of 3·3lb. of carbon rods having a radiating surface of 1·35 sq. ft. One horse-power minute is sufficient to warm 1lb. of water to the extent of 42·7°F. $\left(i.e., \frac{33,000}{772{\cdot}55}\right)$; so that 0·605 H.P. minute should produce a rise of 25·8335°F. in 1lb. of water. Taking the specific heat of carbon at 0·2, the 3·3lb. would require ·066lb. degree F. for a rise of 1 degree. Hence the 0·605 H.P. minute should have raised the temperature of the rods to the extent of $\frac{25{\cdot}8335}{0{\cdot}66} = 39{\cdot}14$°F. But the rise of temperature recorded by the thermometer was only 0·5 degree.

In view of this slow rate of rise, added to the fact that the thermometer-reading remained at times constant for a period of 20 minutes, and in view also of the probability that there could not have been any great waste of energy by heat-radiation from the external surface of the box, I conclude that the average rise of temperature as recorded may be taken as representing the average *available* rise of temperature of the carbon forming the stove. Hence the apparatus fraction of the McTighe heater was $\frac{·5}{39{\cdot}14} = 0{\cdot}0127$, and that of the Burton stove was obviously much less.

Another way of considering the test is as follows:—The difference between the actual temperature of the carbon rods and that recorded by the thermometer could not have been very great; for the reading at the expiration of the longest run (100 minutes) was only 117° F., as compared with 84° F. at the commencement. It is, therefore, reasonable to assume that the average difference of temperature between the stove and the thermometer was, say, 20° F. Now, according to Péclet, 1 sq. ft. of lampblack loses (or absorbs) radiant heat energy in one hour to the extent of 0·8196lb. degree Fahrenheit units for every degree Fahrenheit of difference between its own temperature and that of surrounding bodies. Taking this figure (obviously an excessive one) for the carbons with their surface of 1·35 sq. ft., the radiation per minute for every 1° F. excess of temperature will be $\frac{1{\cdot}35 \times ·8196}{60} = ·018441$ thermal unit; and for 20° F. excess, the emission will be ·36882 unit per minute. But the energy employed is ·605 H.P.=25·8335 thermal units per minute; and, therefore, the apparatus fraction is $\frac{·36882}{25{\cdot}8335} = ·0143$.

It may, however, be urged that the cost of electric heating should be compared with that of the usual method of steam heating, rather than with the more economical but less convenient stove and fire-place system. Let us make this comparison. One pound of coal burnt in the furnace of a steam boiler will convert about 9lb. of water into steam at a pressure sufficient for travel and utilisation in radiators, &c., and each pound of steam should deliver about 250,000 calories for warming purposes. Four pounds of coal, therefore, will, if employed in this manner, give out warmth to the extent of $4 \times 9 \times 250,000 = 9,000,000$ calories; whereas the consumption of the same amount of fuel for electric heating will give 645,850 calories. The electric heating system thus requires $\frac{9,000,000}{645,850}$ or 13·93 *times as much coal as is required for ordinary steam heating.* If the heat be required for smelting, the comparison must, of course, be made with coal or coke consumed direct.

It will probably be admitted that the figures above given are utterly prohibitory as regards any general introduction of electric heating or smelting, though for certain special purposes, such as railroad and street car heating, electric welding, the convenient localisation of high temperatures (*e.g.*, in the Cowles aluminum process) and the like, it may well be that the extra fuel cost of electricity is more than compensated by practical advantages not otherwise attainable.

But the question assumes an entirely different aspect in localities where water-power is procurable, and where fuel is scarce, as, for example, in the case of many mining districts. The cost of installing and maintaining a water-driven electric plant will be moderate, and although the effective output of heat at the point of consumption may still be a comparatively small fraction of the actual water-power employed, its raw material, so to speak, will be obtained without charge. It is in this direction that the next great industrial development of electricity may be looked for. The judicious utilisation of water-power will provide remote mining districts with *fuel*, in addition to mechanical energy and means of transportation, and will thus enable work to be carried on where otherwise all effective labour would remain impossible.

The use of electricity for the actual smelting of ores as distinguished from mere mechanical concentration may seem open to doubt. But it is certain that electricity may be made to provide *fuel* in the literal sense of the word, and fuel, moreover, of a cha

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racter eminently suited for metallurgical operations. The decomposition of water by an electric current is nowadays a phenomenon of quite hoary antiquity; but the actual figures of the case are seldom borne in mind. Yet as 1 H.P. hour, if employed electrolytically, is capable of yielding 7½ cu. ft. of hydrogen and 3¾ cu. ft. of oxygen, it will be seen that practical quantities of reducing and oxidising gases may easily be obtained for use in furnaces or other metallurgical apparatus. It is true that the combustion of the 7½ft. of hydrogen would yield only 645,850 calories, or the equivalent of 0·1898lb. of coal; but the gaseous form of the fuel and its reducing character would render it vastly more applicable and effective. I therefore think it consistent with due sobriety of professional judgment to believe that by this method of utilising electricity many a mine may so far smelt its ores as to largely reduce the cost of carrying them to market, and may also successfully treat various classes of so-called "refractory" ores.

THE ELIHU THOMSON PRIZE.

At the last prize contest instituted by the City of Paris for the best electric meter, the prize of 5,000 francs was awarded to Prof. Elihu Thomson. With the desire that this sum should serve for the development of the theoretical knowledge of electricity, he has requested the general manager for Europe of the Thomson-Houston International Electric Company to offer a prize for the best work on a theoretical question in electricity, and to organise a committee who should propose the subjects, examine the productions, and decide the prize. The following gentlemen have been chosen, and have kindly consented to act as members of the committee:—J. Carpentier, Hippolyte Fontaine, E. Hospitalier, E. Mascart, A. Potier, examiner, B. Abdank-Abakanowicz, secretary of the committee. The committee has decided that the prize should be given for an investigation on one of the following subjects:—

1. The heat developed by successive charges and discharges of condensers under different conditions of frequency, nature of dielectric, and quantity of charge.

2. It has been shown theoretically that when the two surfaces of a condenser are connected by a conducting body, the condenser becomes the source of alternating currents as soon as the resistance of the conducting body decreases below a certain limit. The formula that permits calculating the period of this oscillation has not yet been completely verified. This period of oscillation should be investigated experimentally under conditions such that the exact measure of resistance, capacity, and coefficients of self-induction may be possible, in order to arrive at a complete and precise verification of this formula.

3. When a condenser made with an imperfect insulating material has been charged and then left to itself, the charge is gradually dissipated. The time necessary for the charge to be reduced to a given fraction of its initial value depends only on the nature of the insulating material. It is proposed to investigate whether, as certain recent theories would seem to indicate, analogous phenomena do not present themselves in metallic conductors, and whether these can be shown experimentally.

4. It is proposed to arrange and systematise our present knowledge of the graphical solutions of electrical problems, and deduce from them some general methods as in graphical statics.

The theses presented may be written in any one of the following languages: English, French, German, Italian, Spanish, or Latin. They may be in manuscript, or printed. Each thesis presented must be signed by a pseudonym and accompanied by a sealed envelope bearing the same pseudonym on the outside, and with the name and address of the author inside. The Papers must be sent before September 15, 1893, to B. Abdank-Abakanowicz, consulting engineer, the secretary of the committee, at 7, Rue du Louvre, Paris, who will furnish any further information required.

"Lava" Insulators.—"Lava," or, in other words, steatite, insulators appear to have obtained considerable vogue in the United States. This substance is, it is said, easily moulded and then hardened, and to be acid, water, and heat proof. According to a test made by the Thomson-Houston Electric Company, a cubic inch of steatite has a resistance of 50 megohms, which gives a specific resistance in C.-G.-S. units of $12{\cdot}7 \times 10^{16}$, as against $2{\cdot}27 \times 10^{16}$ for glass (at 200°C.), and $8{,}400{,}000 \times 10^{16}$ for mica.

ON A PROPERTY OF LAMELLAR BI-METALLIC CONDUCTORS SUBJECTED IN ELECTROMAGNETIC INDUCTION.*

BY CH. REIGNIER AND G. PARROT.

The electrical energy of a dynamo machine can be expressed by the following expression:—

$$W = 2\,H\,s\,N\,v\,\Omega\,\delta$$

where H is the average value of the maximum magnetic induction experienced in a revolution by any one of the armature coils of area s; N is the number of magnetic fields, alternately positive and negative, cut by a coil in a single revolution; v the number of revolutions per second; Ω the total section of the armature conductor; δ the current density.

The factors N, s, v, δ are independent of H. If H and Ω were also independent quantities it would be sufficient to give H a limiting value, and to go on increasing Ω in order to increase the available energy. But this is not the case; the magnetic induction depends on the length of the air path (occupied in actual machines by the armature conductors). The experiments of M. Leduc and the researches of the late M. Cabanellas showed that the magnetic induction measured in air varies sensibly inversely as the wave length of the lines of induction in air. Hence, since Ω is proportional to this air length, which has been called *entrefer*, the terms H and Ω vary inversely, and W remains constant.

If we substitute for the copper conductors ordinarily employed thin strips composed partly of a very magnetic and partly of a very conducting metal, placed so that the lines of induction are perpendicular to their thickness, the magnetic flux emanating from the north pole will divide into several bunches of parallel lines very close to each other, and traversing only the magnetic portion of the bi-metallic conductors. The higher the armature conductors are made the more the magnetic flux will tend to pass entirely through the magnetic portions of the strips. In other words, the magnetic induction is constant along the magnetic axis and the tube of force, which envelops the armature circuit, is cylindrical. The available energy in such an apparatus will increase sensibly in proportion to the height of the conductors.

We have constructed a machine based on this principle, and at 500 revolutions have obtained 32,000 watts. The total weight is 750kg., which gives a "specific utilisation" of about 42 watts per kilogramme of machine.

Our machine is not unlike a Faraday disc divided so as to guide the currents generated within it. In order to utilise all the space comprised in the circular crown subjected to induction the circuits consist of circular arcs. The winding is carried out as follows:—Two discs of a certain thickness are built up by means of a number of bi-metallic plates arched according to various radii. These are superposed, and the interior and exterior extremities are united so as to form a closed circuit by joining a plate of the first with one belonging to the second disc.

* *Comptes Rendus*, Vol. CXV., p. 310.

LEGAL INTELLIGENCE.

The St. Benet Fink and St. Nicholas Cole Abbey Faculties.

A sitting of the Consistory Court of London was held on Friday last week in St. Paul's Cathedral, before Dr. Tristram, Q.C., Chancellor of the Diocese of London, who delivered judgment in these cases as follows:—On Monday last, the 29th ult., application was made to this Court to authorise by faculty the construction of transformer chambers or vaults in two City churchyards long disused for burials—one in the churchyard of St. Benet Fink, close to the Royal Exchange, and the other in the churchyard of St. Nicholas Cole Abbey, in Queen Victoria-street—for the use of the City of London Electric Lighting Company (Limited), to enable the Company to introduce electric lighting into those parts of the City in which the churchyards are situated. The construction of these chambers will involve the disturbance of human remains, and their removal and reinterment in some other consecrated burial ground. . . . The church and site and the churchyard of St. Benet Fink were by a local Act of Parliament, 5 and 6 Vic., cap. 101, vested in the Mayor and Corporation of London, with a view to extend the avenues adjoining to the Royal Exchange. The Act provides that as soon as the "said church and burial ground shall be cleared, the same shall be enclosed by a substantial iron railing or other substantial fence, and the residue of the said site and burial ground shall remain for ever unbuilt upon and unappropriated to any purpose except such ornamental purpose. By this section the Court is precluded from dealing with the site of the churchyard, and by the Act the Corporation have now no power to deal with the vaults underneath the site, and the vaults being in consecrated ground this Court has jurisdiction to make such orders in relation to them as the circumstances of the case may require. The question is whether it has under the circumstances of this and the next case

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discretionary power to make the orders asked for. The Commissioners of Sewers have granted permission for the erection of these chambers in narrow thoroughfares, but have refused permission in the present case, as its construction would disarrange the telephone and telegraph and gas and water companies' pipes; and, owing to the site required being a crowded thoroughfare, it would be for other reasons objectionable. The Company has also approached owners of adjoining property with a view to arrange for a sale of the site required without success. They have no compulsory powers to compel a sale of land for the purpose under their Act; and in the result, if this application were to fail, the area in question will remain unlighted by electric light. The petitioners have thus made out a strong case of urgency in the interests of the parishioners and public in favour of their application. It also appears that several applications have been made to the Company to light the City churches for Sunday evening services, which are well attended, and it is, therefore, against the interests of the Church that the scheme should fail. The Company also offer the payment of £25 to be appropriated towards the church expenses of the parish church. The special facts in support of the application in the case of St. Nicholas Cole Abbey are as follows:—The church and churchyard abut on Queen Victoria-street. Part of the churchyard was many years ago appropriated, under an Act of Parliament, for the construction of the District Railway. The chamber required cannot be constructed under the streets, owing to there being a subway for the supply pipes of the water and gas companies, and the Company have failed to acquire a site by private purchase. The proposed chamber will supply from 20,000 to 25,000 incandescent lamps, and there have already been applications for 5,000 lamps. The church is lighted with electric light, and the Company offer an annual payment of £30 towards the church services. If the faculty is refused the electric lighting of the church will cease. The question before the Court is whether it has a discretionary jurisdiction in the matter; and if it has, whether it would be proper exercise of it to grant the faculties prayed. The Court is of opinion that it would not be exceeding its jurisdiction in granting the faculties prayed, and that under the exceptional circumstances of these two cases it will be exercising a sound discretion in granting them. It therefore decrees the faculties as prayed—the faculties not to issue within 15 days, and advertisements to be inserted in *The Times* and *City Press*. So as to enable any members of families buried in the vaults to make application to me in chambers relating to their removal, a proviso will be inserted in the faculty permitting the removal of remains, if desired, by members of the families to any consecrated burial ground selected by them. The other remains will be removed to the parochial burial grounds of the respective parishes for reinterment in the consecrated portion of the cemetery.

Mr. Arnold Statham appeared for the petitioners.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 27, 1892.

Electrical Stocks.—The market for industrial stocks has been exceedingly buoyant for the past week on the exchanges in both Boston and New York. The stocks of nearly all electric companies are quoted at higher prices than at any time during the year. Westinghouse stock, for instance, has been continually advancing until it reached 40 in the Boston market yesterday afternoon. This is the highest point at which it has been sold since the financial difficulties which brought its stock to the lowest point it ever sold, that is 7 on a par value of 50. The Wall Street *Daily Bulletin* is authority for the statement that the proposition which was made by the General Electric Company to purchase the Westinghouse stock was on the basis of $30 for the common and $50 for the preferred, both stocks being par at $50. This proposition was declined as being too low, and it is understood that before long another offer will be made in which the price offered will be increased. This was mentioned in a former letter as likely to take place immediately after the decision in the Court of Appeal on the Edison incandescent lamp patent is handed down. This is expected early in the fall, and no one doubts that it will be in favour of the Edison Company, which, under the present management, of course means in favour of the General Electric Company. The General Electric stock, of which the par value is $100, was quoted on the Boston exchange at $117½.

Niagara.—Prof. W. C. Unwin and Prof. Geo. Forbes, of London, met on the 22nd at Niagara Falls with the Cataract Construction Company to discuss the ways and means pertaining to the projected transmission plants on the American and Canadian sides of the Falls. The proposed construction of the Canadian tunnel was given definite form by investing Prof. Unwin with the necessary authority to prepare plans for the projected tunnel. This is to be 800 feet long, and will, therefore, not occupy any extensive amount of time in its construction. When the two tunnels are finished it is proposed to have the transmitting system of the one side connect with that of the other so that in case of any breakdown current may be transmitted by the other. It is stated that Profs. Unwin and Forbes will remain at the Falls for a week or more looking after the work of the project, which is now well under way.

Sales at Chicago Exhibition.—Concerning the sale of merchandise at the World's Fair, Secretary Crawford, of the Exposition Committee on Ways and Means, has written a letter, which very fully covers the subject. The following is an extract:—

> The sale of goods for immediate delivery and consumption will be prohibited in all the buildings except where concessions or privileges are specifically given on the merits of the individual cases, but no concessions will be granted for general merchandising either within the buildings or within the grounds of the Exposition. The exception treated of refers especially to Oriental goods, and such natural curiosities as are peculiar to the countries and sold by the natives of such countries. The Exposition even proposes to restrict the sale of these natural curiosities, as if the door is open which will permit general sales of this kind the bazaar feature will easily and quickly develop. The exhibits may be used as samples from which orders may be taken and filled from a depôt or storehouse either outside the grounds, in Chicago, or from the home office of the exhibitor. This is a matter over which the Exposition cannot exercise any jurisdiction, and it therefore claims no authority whatever.

Electric Traction in New York.—A very important franchise was granted last week to the Union Railway Company, a concern which is to control and operate an extensive system of electric railways in the upper part of New York City, commonly called the Annexed District by city residents. An idea of the size and importance of the system may be gained from the fact that the franchise granted specifies that the Company's payment of revenue to the city is not to begin until the daily revenue is $1,700, and it is expected that this provision will exempt the Company from taxation for ten years; in other words, the system as at present planned is expected to bring the Company a daily income of $1,700 at the end of about ten years. It is provided that when the income amounts to this figure the Company is to pay into the city treasury 1 per cent. of its earnings, and that when it amounts to double this figure the Company is to pay 2 per cent. A great deal of opposition has recently been manifested in and around New York City to the overhead trolley system, and it was quite a surprise, even to the friends of the trolley, to find that a franchise of so great importance had been granted to advocates of the overhead system within the city limits. This is regarded as second in value to the Broadway franchise of New York City.

American Association for the Advancement of Science.—The American Association for the Advancement of Science held an interesting meeting at Rochester, N.Y., beginning on Wednesday, August 17th. This was the forty-first annual meeting of the Association, and was quite largely attended, although it is by no means as important a meeting among American scientists as the British Association is among the scientists of Great Britain. The electrical subjects come up for discussion in the section devoted to physics as well as in that devoted to Papers on mechanical and engineering topics. Prof. Ed. B. Rosa, of Wesleyan University, Middletown, Conn., presented an interesting Paper on electro magnetism. Prof. A. E. Dolbear, of Tuft's College, exhibited some models designed to illustrate electro-magnetic relations. Prof. Whitman, of Adelbert College, read a Paper on magnetic disturbances caused by street railway currents. Mr. Chas. B. Thwing read a Paper on a photographic method of mapping the magnetic field, and Prof. Whitman, in the physical section, read another Paper on the constancy of volume of iron in strong magnetic fields. Prof. E. L. Nichols, of Cornell University, read a Paper on the distribution of energy in the spectrum of the glow lamp, while Prof. B. W. Snow, of Bloomington, Ill., read one on the distribution of energy in the arc. One of the most interesting Papers, electrically speaking, was one by Prof. J. E. Kershner on electric lights for astronomical instruments.

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CORRESPONDENCE.

ELECTRICAL TRACTION AND COVERED CONDUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to your remarks last week on above, in justice to others as well as to myself, allow me to give the following facts:—

That iron had been used to cover a conduit half a century ago is true, but I do not think it was ever in the form of a strip, either continuous or free. It was a compound construction of leather and hinged flaps. Moreover, the object was entirely distinct from the present. It was to make an air-tight or water-tight joint along a pressure main on a railway. Even the description of this as a rope valve conveys a wrong impression, as it is fastened all along one edge. A real rope valve has, however, been suggested for this purpose in a publication by Talbot and Hiddiard many years ago; but it is a distinct idea to utilise any such class of opening for a modern electric street conduit, though the speed of 60 miles an hour, at which they were successfully worked, gives a good idea of its practicability. Since instituting my researches and practical experiments I discovered that I cannot take credit even for this idea. Patents have been issued in the United States to Blake for a strip of rubber laid on a bare conductor, and set on the road surface, the strip being free and raised by stretching it sufficiently for a pulley to run underneath. The intended object of this inventor, as stated in his patent, was to avoid the use of a chambered conduit with the conductors supported inside.

Now this we know is the only practical way of using a bare conductor in a street conduit, for the leakage throughout any such system as Blake's would be inadmissible. This was recognised by Chas. W. Van Depoele, who soon followed with the chambered conduit, having rubber or other insulating soft cushions on each side of the slot, which were wedged open by the connecting conductor travelling with the car. Prof. Elihu Thomson, evidently seeing the weakness of such cushions, changed them for a number of stout fibres like a brush.

Neither of these, however, fully answered the requirements, they do not seal the conduit enough, they have no transverse strength, and therefore could not be used to cover a wide opening, which is the most necessary thing of all to obtain success. Even were the Blake or old rope suggestion used in my system with the chambered conduit, the want of transverse strength, the bad fitting, the liability to wedge down, and the deterioration of the material, would make them useless. There are many other points, notably at the crossings and turn outs, which make the construction of a number of bars of metal or equally hard substance connected by sliding joints into a continuous strip or rail, the only practical and workable article that any experienced man is likely to recognise for this work.

I do think that "this mode of protecting a covered conduit" is entirely and valuably original, if only from the American legal point of distinction that it makes of commercial practical value a thing already known, but the fact that patents are now granted nearly all over the world, including the most careful and Conservative Government offices, best attests to its true originality.—I am, Sir, &c.,

Britannia Works, Helsby. CARL T. B. BRAIN.

[Mr. Brain need hardly concern himself about the Clegg and Samuda closed conduit as an anticipation of his patent. We merely described this old invention as a curious coincidence, and an example of history repeating itself.— ED. *E.*]

HIGH VOLTAGE LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your Notes of September 2nd you refer to Messrs Khotinsky as if they were the only makers of high voltage lamps, whereas we have been making them for several years; and during the last six months we have made considerably more than 10,000.

I quite believe that credit is due to Captain de Khotinsky of being one of the first to commence the manufacture of these lamps commercially, but where there is a demand manufacturers are seldom wanting, and the whole question is simply one of economy.

Briefly stated, the scientific efficiency or economy of a lamp is the total useful candle-hours, as compared with the total energy or watts consumed; whereas the commercial efficiency, or economy, are those two factors, *plus* the cost, not only of the lamp itself, but also the trouble of replacing it when broken, and the cost of supplying energy to it.

Captain de Khotinsky very correctly points out that these lamps cannot be made for the same price as ordinary lamps, and I doubt much whether the 25 per cent. extra charge is really sufficient to pay the makers considering the small demand.

A central station man can easily see if 25 per cent. extra in the cost of lamps will be compensated by the further economy in conductors which is a simple case of interest on the copper used in them.—Yours, &c., C. FARADAY PROCTOR.

Ingénieur et Chef de fabrication, Cie. Gle. des Lampes Incandescentes (Edison and Swan), Paris.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—Our advertisement columns contain an announcement that the Board of Lighting Inspectors for Chertsey are prepared to receive proposals for lighting the district with electricity. Particulars can be obtained of Mr. E. H. Gale Crowdy, Clerk to the Board, Chertsey.

———— Messrs. George Angus and Co. (Limited), Dale-street, Liverpool, invite tenders for various railway stores, including 20 tons of galvanised telegraph wire, 100 tons of galvanised iron, 22 tons of zinc, &c. Tenders are to be in by noon on Monday, the 19th inst.

TENDERS ACCEPTED.—The Hanley Town Council on Tuesday accepted the tender of the Brush Electrical Engineering Company (Limited) to light the town by electricity, the amount of the tender being £15,760.

———— The Dolgelly Local Board have accepted the tender of Mr. Hall, of Liverpool, to light the town by electricity during the coming winter for the sum of £80.

————. The Uxbridge Local Board have accepted the tender of Mr. G. Jennings, of the Stangate, Lambeth, for providing and fixing complete an electrical tell-tale with electrical appliances and underground wire between their waterworks and reservoir, 1¼ miles apart, for the sum of £84. 15s.

————. The tender of Messrs. Blaikie Brothers (Limited), Aberdeen, has been accepted to supply girders for the Dundee electric lighting station at £224.

————. The Electric Lighting Committee of the Derby Corporation have accepted the tender of Messrs. G. Fletcher and Co., of that borough, for the supply of boilers and accessories for the electric light station.

TENDERS RECEIVED.—The following tenders have been received from Newcastle firms for the plumbing, gas-fitting, and electric light work in connection with the re-building of an inn and some warehouses in Newgate-street, Newcastle-on-Tyne:—

	£	s.	d.		£	s.	d.
Emley and Sons	550	0	0	J. Somerset and Co.	475	0	0
C. Patterson	527	0	0	W. Burn	466	16	0
A. Scott	506	5	8	R. Herron	460	9	8
H. Walker and Co.	499	4	0	H. Simpson	450	16	9
E. Johnson and Co.	492	0	0	Bland Bros.	445	0	0
Threlkeld and Wallace	490	8	0	R. J. Charleton and Co.	440	0	0
J. France	481	10	0	M. Gibson (recvd. too late)	485	0	0

ABERDEEN.—The Aberdeen Town Council resolved on Monday to proceed with the private lighting of a certain district of the town by electricity. The Council propose to undertake the work of supplying electricity, the estimated cost of the undertaking for the limited portion of the city being £24,460.

BELFAST.—It was announced at the meeting of the Belfast Corporation on Thursday that the Gas Committee had resolved to recommend the outlay of £300,000 to supply the electric light for the centre of the city.

BLACKPOOL.—The Town Council on Tuesday resolved to purchase the electric tramways in the borough for the sum of £15,750.

DUNDEE.—The Secretary of State for Scotland has sanctioned the raising by the Gas Commissioners of a loan of £20,000 for the execution of works under the Dundee Electric Lighting Order 1890.

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EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—Under the management of Mr. C. M. Downie, the Edison and Swan Company have opened extensive show rooms and warehouse at 110, Cannon-street, London, E.C., where a large stock of every variety of Edison and Swan incandescent lamps, from 2½ to 1,500 c.p., will be on sale. We understand that arrangemen's have been made for stocking not less than 20,000 lamps in these City premises, which have been opened to meet a large demand in the E.C. district. In addition to the special manufactures of the firm in incandescent lamps, a large display of the latest designs in lamp fittings, shades, and globes will be on view, as well as some special designs in electroliers and ships' fittings. Casings and electric light cables are to be a special department of the new show rooms, and included in the stock already showing are many handsome designs in bracket lamps and electroliers. Provision is made for the stocking of a limited assortment of switch boards and Cardew measuring instruments, and a quantity of various styles of the well-known "Tumbler" switches, lamp holders, suspender lamps, small incandescents for medical and similar purposes, and all kinds of supplies for electric lighting installations. A choice selection of out-door designs for the illumination of winter gardens and similar displays can be seen, and a large variety of incandescents in all colours and shapes will be obtainable for table decorations and "occasional" installations. The new premises occupy 100 feet frontage, 50 feet of which is in Cannon-street, and doubtless, owing to the central position of these show rooms and offices, a large additional business will result. The show rooms are neatly wired; the casings forming a part of the ornaments of the ceiling and wainscots. The large quarto catalogue of the Edison and Swan manufactures, with which many of our readers are familiar, can be obtained on application.

MADRID.—The Royal palace is lighted by gas made on the premises, but instructions have been given to instal the electric light. Some 1,800 lamps will be required, and the estimates sent in range from £14,000 to £20,000.

TAUNTON.—A petition has been forwarded to the Board of Trade by several ratepayers asking the Board to refuse its consent to the proposed purchase by the Town Council of the electric light works, plant, &c., of the Taunton Electric Light Company for the sum of £9,300. The petitioners say that the Town Council decided on the purchase, notwithstanding the adverse report of an expert electrician called in by them, and that the acquirement and extension of the works, &c., would result in a dead charge on the rates of nearly £2,000 per annum. The Laing, Wharton and Down Construction Syndicate (Limited) have addressed a letter to the Town Clerk of Taunton asking to be kindly furnished with the names of the valuers suggested some time ago by the Board of Trade for the purpose of valuing the electric light works, in addition to that of Mr. Gisbert Kapp. TheSyndicate also offer to bear the entire expense of another valuation.

COVENTRY ELECTRICAL ENGINEERING COMPANY.—We are asked to state that owing to increase of business this firm have taken larger premises situate at Ryley-street, Coventry. Mr. W. J. Butlin has recently joined the firm.

SUNBEAM LAMP COMPANY (LIMITED).—This Company announce that although they have temporarily ceased the manufacture of the "Sunbeam" lamp, they are still supplying their patent "Sunbeam" holder, which they claim to be the best, simplest, and neatest holder in the market for large incandescent lamps. They further say that the Edison and Swan United Electric Light Company (Limited), to meet the growing demand for "Sunbeam" holders, are now making lamps to suit these holders.

WIRING TABLE.—We have received a copy of Messrs. Walter T. Glover and Co.'s new wiring table. It gives all the figures and formulæ likely to be of use to an electrical engineer in calculating the best size of wire to be used in house conductors or street mains. There is a column showing the safe carrying capacity of the wires with a current density of 1,000 amperes per square inch; this allows an approximate loss of 2½ volts per 100 yds., and thus facilitates calculations.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—With the appropriate heading of "Are you there?" this Company issue an illustrated pamphlet calling public attention to the advantages of the telephone for a number of useful purposes. Commencing with the domestic telephone, the pamphlet deals with the advantages the instrument offers to proprietors of hotels and boarding houses, theatres and other places of public entertainment and amusement, churches and chapels, offices and works; for military and naval purposes, in mines and collieries, &c. The Company claim for their instruments that they are superior in manufacture and thoroughly reliable. For use in mansions and private houses, the cabinet work can be supplied to harmonise with the surroundings. Tradesmen who instal the Company's instruments would do well to obtain a supply of these pamphlets for probable customers.

ELECTRICAL INSTRUMENTS.—We have received from Mr. R. W. Paul, of 44, Hatton-garden, a new catalogue of electrical instruments. Several of these have been recently described in our columns. Among his specialities are a flat resistance coil allowing a definite temperature to be quickly arrived at and measured; resistance boxes, the coils of which are put in circuit by plugs connected to stout flexible cables; variable carbon resistances; Ayrton-Mather and other galvanometers.

THE SILVERTOWN COMPANY.—This Company have issued their revised list of particulars and prices of the various kinds of Leclanché battery made by them. The list is illustrated.

THE CHILI TELEPHONE COMPANY (LIMITED).—This Company has recently obtained an important concession from the Chilian Government, whereby the latter binds itself to use the Company's telephones in all the public offices to the exclusion of all other systems. The contract is to remain in force for ten years, and the rates paid are to be the same as those actually ruling, but subject to certain modifications dependent upon the rate of exchange. In return the Company is under an agreement to expend the sum of £30,000 within the next few years in improving its installations and plant.

MESSRS. A. HALL AND CO.—This firm have installed the electric light on the premises of Mr. W. Boote, furniture storer, Elizabeth-street, Liverpool. There are forty 16 c.p. incandescent lamps, and a 3,000 c.p. arc lamp within and without the building.

MESSRS. F. C. ROYCE AND CO.—This firm have recently put down an electric lighting plant at the Stanley Colliery, Derbyshire.

POOLE AND WHITE (LIMITED).—A petition for the compulsory winding up of this Company was presented on the 1st inst. by Mr. L Hervé, 90, Clerkenwell-road, and is down for hearing on Wednesday next, the 14th inst.

HENLEY TELEGRAPH AND ELECTRIC CONSTRUCTION COMPANY (LIMITED).—A petition for the winding up of this Company was presented on the 23rd ult. by Mr. A. P. Matheson, merchant, of 9, Cornhill, E.C., and is appointed for hearing on October 25th.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

August 6, 1892.

14,239. G. HOOKHAM. Birmingham. Improvements in electricity meters.

14,250. S. A. ROSENTHAL and V. C. DOUBLEDAY. London. Improvements in secondary batteries.

August 8, 1892.

14,296. B. DEATH. London. Improvements in arc lamps.

14,309. F. TEAGUE, E. F. MOY and J. A. ILIFFE. London. Improvements in electricity meters.

August 9, 1892.

14,360. G. DAVIS. London. An electric bell.

14,363. W. F. GARDNER. London. Improvements in the method of and apparatus for transmitting and receiving time signals over main and local electrical circuits.

14,395. J. W. CANN and R. E. COMMANS. London. Improvements relating to electric furnaces for the treatment of auriferous sulphide ores and for other purposes.

August 10, 1892.

14,323. A. WRIGHT. Brighton. Improvements in electricity meters.

August 11, 1892.

14,481. H. HATELEY. Birmingham. Improvements in decorating chandeliers, gasaliers, lamps and electric light fittings.

14,489. T. CUTTRISS. Leeds. Improvements in governing devices for electro-motors.

14,512. H. BINKO. London. An electric combination street alarm box for fire, police, and other purposes.

14,516. H. W. C. BAKER. London. A new or improved electric or other flashing signal lamp. (Lewis Clinton Baker, H.M.S. Mercury.)

14,533. R. N. LUCAS and A. G. NEW. London. An apparatus for converting alternating currents of electricity into direct currents.

August 12, 1892.

14,558. C. M. DORMAN and R. A. SMITH. Lancashire. Improvements in lamp-holders for incandescent electric lamps.

14,569. S. HINDLEY. Sheffield. Improvements in grooved wood cases of electrical cables or wires.

August 13, 1892.

14,658. A. J. SMITH. London. Improvements relating to electric accumulators or secondary batteries and to the manufacture of plates or electrodes therefor.

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14,659. H. H. Lake. London. Improvements in or relating to electric accumulators. (F. C. Jenkins, Germany.)

14,660. J. Rousseau. London. Improvements in and relating to the manufacture of plates for electric accumulators.

August 15, 1892.

14,674. A. Marr. Manchester. Improvements in electric telephonic trasnmitting apparatus.

14,676. A. Cuthbert. Maidenhead. Improvements in commutatorless direct current dynamo electric machines.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

7,278. Percival. Electric switches.

11,712. Bull. Electric batteries.

12,703. Hawkins and Newton. Electric switch-boards.

12,954. Bennett. Electrical parcel exchange system.

13,125. Howard. Carbon holders and screens for electric welding.

13,280. Munro. Electrical conduits.

13,492. Elmore. Electrical propulsion of vehicles.

14,096. Thompson. Combination electric lock.

14,834. Heys (Brown). Electrically propelled vehicles.

15,377. Whitehead. Electric globe gallery, &c.

15,834. Drake and Gorham. Carriers for electric lamp shades.

16,250. Hammond and Hall. Dynamo machines.

16,293. Heys (Heilmann and another). Electrically propelling ships, &c.

16,300. Snell and Woodhouse and Rawson United (Limited). Electrical fittings.

16,641. Lewis. Coupling for lightning conductors.

16,977. Whincop. Lightning rod staples.

16,991. Higgins. Type printing telegraphic apparatus.

17,227. Howell. Electric cables.

17,324. Parfitt, G. J. and G. J. T. J. Electric lighting.

18,083. Harness. Electrical belts, &c.

18,179. Gay and Hammond. Dynamo-electric machines.

18,837. Siemens Bros. and Co. (Limited). (Siemens and Halske.) Electric railways.

1892.

3,631. Bidtel. Compound and insulated wires.

3,875. Coerper. Electric motors.

11,017. Steiner. Phonogram cylinders.

12,057. Linville. Printing telegraphs.

12,191. Mills (Johnson). Electric railways.

12,306. Lee. Secondary batteries.

12,417. Mitchell. Electric brazing and soldering.

12,436. Lake. (McCarthy.) Electric insulators.

12,442. Adler and others. Electrically lighting and heating railway, &c., vehicles.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades' Directory and Handbook, 1892, pages 308-322, *&c., &c.*

ADOLPH CROSBIE (LIMITED).—This Company has been registered with a capital of £15,000, in £5 shares, to carry into effect an agreement for the acquisition of the undertakings of the Red Oxide Company, and of the Cheshire Carrying Company, hitherto carried on at Wolverhampton and elsewhere, and to develop and turn to account the same.

C. AND E. GRAY (LIMITED).—This Company was registered on September 1st, with a capital of £5,000, in £5 shares, to carry on the business of brassfounders, cabinet brassfounders, and ornamental metal workers carried on by Charles Gray and Edwin Gray at Exeter-street, Birmingham.

EMILE LANSARD SYNDICATE (LIMITED).—Registered on August 23rd, with a capital of £10,000, in 400 Six per Cent. Cumulative Preference, and 1,600 Ordinary Shares of £5 each, to acquire the business of engineering machinist, general press and press tool maker and dealer in and manufacturer of stamped and pierced metal goods and electrical fittings, carried on by Emile Lansard, at 216, Goswell-road, London, E.C.

NOTTINGHAM MACHINISTS' COMPANY (LIMITED).—This Company was registered on September 1st, with a capital of £30,000 in £1 shares (of which 30 are founders'), to carry on the business of cycle manufacturers and otherwise, carried on by a Company of the same name at Ilkeston, Derbyshire, and to carry on the business of manufacturers of and dealers in, and to buy, sell, let on hire, and repair, every description of apparatus and appliances required for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity, and generally to carry on the business of electricians and engineers in all their branches.

MISCELLANEOUS.—Bedson Wire Company (Limited), wire drawers and wire manufacturers; capital, £50,000, in £100 shares.——Carboid Oilless Bearing Company (Limited), owners of patents and inventions relating to the manufacture of carboid; capital, £2,000, in £1 shares.——New Weighing Machine Company (Limited), makers of weighing machines, electrical engineers, &c.; capital, £20,000 in £1 shares.——Robert Dempster and Sons (Limited), gas, chemical, and hydraulic engineers; capital, £3,000, in £10 shares.

ELECTRIC FITTINGS HIRING AND MAINTENANCE COMPANY (LIMITED).—The statutory return of this Company, made up to February 23, 1892, was filed on August 15, 1892. Out of a capital of £200,500, divided into 40,000 ordinary shares of £5 each, and 500 founders' shares of £1 each, seven shares have been taken up, but no calls made. The original signatories to the Memorandum of Association are the only shareholders.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—The annual return of this Company, made up to August 9, 1892, has been filed. The Company was registered on July 11, 1873, with a capital of £3,000,000, in £10 shares, and since that time the capital has been raised to £5,000,000, divided into 250,000 ordinary and 250,000 preference shares of £10 each, 180,227 ordinary and 180,042 preference shares have been taken up, the full amount called, and all calls (£3,602,690) paid.

RUSTON, PROCTOR, AND CO. (LIMITED).—The annual return of this Company, made up to June 14th, has been filed. The whole nominal capital of £250,000, in £10 shares, has been taken up, of which 7,500 shares have been issued as fully paid. The full amount has been called on the remaining shares, and all calls (£175,000) have been paid.

SHEFFIELD TELEPHONE EXCHANGE AND ELECTRIC LIGHT COMPANY (LIMITED) (in Voluntary Liquidation).—The annual return of this Company, made up to August 1st, has been filed. The Company was registered on August 28, 1890, with a capital of £100,000, divided into 2,000 preference and 8,000 ordinary shares of £10 each, to take over as a going concern and carry on the business of a Company of the same name, which was incorporated September 11, 1888. At the time of making up, 4,000 ordinary, and 1,162 preference shares had been taken up, of which the ordinary shares had been issued; with £8 considered as paid on each to the shareholders of the old Company. Upon the preference shares the full amount has been called, resulting in the payment of £11,440, leaving £180 in arrears. The principal shareholder is John Tasker, of Crookes House, Sheffield, who holds 3,090 ordinary and 100 preference shares.

SHERRIN ELECTRIC POWER GENERATOR COMPANY (LIMITED).—This Company has, we understand, been struck off the list of joint-stock companies.

CITY NOTES, &c.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, this Company's £125,000 Four and a-Half per Cent. Perpetual Debenture Stock.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 4th were £737, as against £672 for the corresponding period of last year, being an increase of £65. The total receipts for half-year amount to £7,690, against £7,069 in the corresponding period of 1891, being an increase of £621.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts for the month of August were £3,100, as compared with £3,111 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the month of August were £1,884, against £1,631 for the corresponding period last.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the month of August amounted to £49,069, against £53,398 in the corresponding period of 1891.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of August amounted to £42,035, and to £41,791 in the corresponding period of last year, an increase of £244.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for August, 1892, amounted to £23,600; and from January 1st to August 31st to £175,600. In the corresponding months of 1891 and 1890 the amounts were £189,400 and £181,000 respectively.

NEW ZEALAND ELECTRICAL SYNDICATE (LIMITED).—This Syndicate, whose offices are situate at 53, New Broad-street, E.C., are asking for £20,000 capital in 2,000 shares of £10 each; the authorised capital being £100,000. The Syndicate was incorporated in December, 1890, to obtain electric lighting concessions in New Zealand and elsewhere, to take over certain central stations erected by the Gülcher Electric Light and Power Company (Limited), at Wellington, New Zealand, and to take over the benefit of a contract between that Company and the local authorities of Wellington for lighting the streets of that city. By an Act passed in 1891 the Syndicate is authorised to supply the City of Wellington with electric current, and in the Act the Corporation reserve powers to purchase the undertaking at the end of 10, 14, or 21 years, upon paying to the Syndicate the capital invested, and making up its average dividends to 10 per

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cent. for the period which has expired after the purchase takes place. From calculations made by the Directors it is estimated that an immediate dividend of 5 per cent. may be relied upon. In addition to the Board of Directors there is a local Board in New Zealand, the Managing Director there being Mr. A. I. Suckling-Baron, M.I.E.E. The secretary is Mr. T. C. Morgan. Amongst the English Board of Directors are Mr. D. de Castro, Mr. G. Grewing, Mr. M. S. Vanderbyl, and Mr. J. Evelyn Williams, M.I.C.E.

ROCKHAMPTON (QUEENSLAND) GAS AND COKE COMPANY (LIMITED).—The Directors' report of this Company was recently issued, and the Directors announce that since the last meeting the bulk of the electric lighting plant had arrived and was in course of erection. The Company appears to have issued debentures in anticipation of the demand for the electric light, a portion of which was devoted to the erection of a new gas-holder, and, notwithstanding this diversion, the various extensions decided upon by the Directors appear to be making a good return to the shareholders. The last dividend declared was at the rate of £10 per cent. per annum.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 2, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,106.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated receipts of this Company for the fortnight ended August 31, 1892, were £1,939, compared with £2,428 for 1891, showing an increase of £489.

COMPANIES' SHARE LIST.

Present Amount	Amount of Shares.	Last Dividend	Name.	Previous Week's Price, Aug. 31.	Price Wednesday, Sept. 7.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Sept. 7. Highest.	Lowest.
			TELEGRAPHS						
£1,247,720	Stock	12/6	Anglo-American	47 48	48 49	5 7 0	Jan., Apr., July, Oct.	48½	..
£2,576,140	Stock	25/0	Do. Preferred	87½ 88½	89 90	6 3 7	" "	90	89½
£2,576,140	Stock	5/0	Do. Deferred	10½ 10⅝	10¼ 10⅜	..	" "	10⅜	10¼
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	100½	..
180,000	£10	3/0	Brazilian Submarine	10⅜ 11⅛	11¼ 11⅝	5 19 2	Mar., June, Oct., Dec.	..	..
£66,200	£100	5%	Do. 5 per Cent. Bonds	100 103	103 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	105½	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	160 165	160 165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine xd	11 12	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10% xd	17½ 18½	17 18	5 11 1	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3⅝	3½ 3⅝	4 16 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅜ 11⅝	11⅜ 11⅝	6 0 2	Jan., Apr., July, Oct.	11⅝	11 15/16
400,000	10	5/6	Eastern	14⅜ 15	14⅜ 15⅛	4 6 8	" "	15⅛	14⅝
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16	15⅛ 16	3 15 0	" "	15⅝	15 7/16
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	109 112	110 113	3 10 10	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15 15½	15 15½	4 12 7	Jan., Apr., July, Oct.	15½	15 7/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 9	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103 106	103 106	3 15 16	February & August	101½	..
180,227	10	8/0	Globe Telegraph and Trust	10½ 10⅝	10½ 10⅝	4 12 4	Jan., Apr., July, Oct.	10⅝	10 5/16
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	15⅝ 15⅞	3 16 10	" "	15 5/16	..
180,000	10	5/0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1893 xd	107 110	105 108	4 12 7	March & September	105½	..
17,030	25	37/6	Indo-European	41 43	42 44	5 13 8	May and November	43½	42½
28,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures xd	108 111	105 103	5 11 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October..	..	..
2,331	£100 Cert.	£1½	Submarine Cables Trust 6%	115 120	116 121	4 19 2	" "	119½	..
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures x1	101 104	100 103	4 17 1	March & September	100½	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 105	7 12 5	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9¼ 9⅜	9¼ 9⅜	6 3 1	May and November	9⅛	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
61 242	15	6/0	Western and Brazilian	8¾ 9⅛	8¾ 9⅛	6 9 7	" "	9⅛	9
33,129	7½	1/8	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 7	" "	6½	..
33.129	7½	4/6	Do. 5 per Cent. Deferred	2⅜ 3⅛	2⅜ 3⅛	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£ 37,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123 128	123 128	5 9 5	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds xd	100 103	97 102	5 17 8	March & September	..	..
			TELEPHONES.						
234,360	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅜ ⅝	⅜ ⅝	6 10 10	May and November	..	..
120,000	£1	4½d.	Oriental (11s. paid)	1/16 1/8	1/16 1/8	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅜ 5	6 0 0	June and December	4⅛	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13⅜ 14⅛	13⅜ 14⅛	4 4 3	" "	14⅛	13⅜
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13 13⅜	13⅛ 13⅜	4 7 3	" "	13 7/16	13 1/16
430,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109 111	109 111	4 1 1	January and July ..	110½	..
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	9½ 10½	10 10½	..	..	10½	10½
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	2½ 3½	2½ 3½	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5½	5 5½	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 5⅝	5½ 5⅝	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/8 3 9/16	3 7/8 3 9/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	..	March	..	..
111,000	5	..	London Electric Supply	1⅜ 1½	.. ..	..	..	..	..
48,000	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7½	6½ 7½	..	..	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5	4 5	..	..	..	..
18,680	£5	2/6	St. James' and Pall Mall	7½ 8	7¾ 8½	..	..	8	7¾
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	..	..	8½	8½
43,858	5	3%	Westminster Electric Supply (fully paid)	5½ 6½	5½ 6½	2 3 0	..	6½	6
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1'9	Brush Electrical Engineering	2⅞ 3⅛	3⅛ 3⅜	..	..	3⅛	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2⅛	2 1/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5⅝	5⅝ 6	6 1 9	January and July ..	..	..
12,139	5	17%	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	12/0	Electric Construction	4⅜ 5½	4½ 5	..	..	5 1/16	4 15/16
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜ 2⅝	2⅜ 2⅝	..	..	2 1/16	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha & c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	21½
£300,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	7/16 ½	.. ..	..	..	..	..
78,949	5	2/9½	Swan United (£3. 10s. paid)	3 3¼	3½ 4	9 12 6	May and November	3⅞	3½
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	42 44	5 9 3	March and July.....	42½	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅛ ¼	⅛ ¼	..	..	..	..
—	£5	5%	Do. Preference (fully paid)	2½ 3	2½ 3	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway			..	..	..	..
60,000	£10	½%	City and South London Railway xd	3⅛ 3½	2½ 3⅛	1 8 6	..	..	..

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THE ELECTRICIAN:

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NOTES.

Mr. Binswanger in his letter which will be found in our Correspondence columns, while sticking to his guns, "doth protest too much;" he has a good case, and it is a pity to spoil it by exaggeration. When he says "nor has a single fire occurred which could be traced to electricity as its cause" in England, of course he is thinking of the oft-repeated claim that no fire has occurred where the Phœnix rules have been enforced. This is highly creditable to their inspector, but it is common knowledge; no one can deny the great value of his exertions, but it is possible to overestimate them. Mr. Binswanger's *précis* of our remarks in his third paragraph is a little crude, and he asks our reasons for supposing that matters in America are taking their best possible course. We see in the first place that they are, if we may venture to say so, on the right track with their porcelain fittings, &c. The quality of the glaze is a refinement which need not concern us here, especially in connection with the American climate; and the indiscriminate method of fixing screws is a matter to which only a portion of our manufacturers have yet paid attention, but which is now receiving the care which it deserves. For these and a dozen other details Mr. Binswanger says that we have to thank Mr. Musgrave Heaphy. We do not underestimate the importance of details; all work is an accumulation of details. We should rather have credited Mr. Heaphy with the principles of which these details are the expression. Americans seem to be beginning to appreciate the principles, and surely they, better than any other nation, may be expected to invent details, their really strong point.

Further than this we really think, even if we have to differ diametrically from Mr. Binswanger, that Americans, with their enormous experience, and with requirements and habits which differ so widely from ours, are able to look after themselves, and to formulate their own rules and methods of inspection. If in the course of the next ten years their new rules pass through nineteen editions as the Phœnix rules have done, we hope that they will take the eighteen opportunities of bringing them properly up to date, so that they may, until the next edition, be self-explanatory. Mr. Binswanger asks if "during the past stage of electrical manufacturing, and even at the present moment, any more definite rules could possibly be devised without being subject to almost weekly alteration." Here we must differ. The rules of the Institution of Electrical Engineers, issued in 1883, have been only once remodelled. So far from being "hard and fast," they have become practically obsolete, simply because they are not up to date. Revise by all means, but surely once in six months is often enough. And (*pace* Mr. Binswanger with his weekly issue) if so, why not let them bear a definite interpretation until the next edition?

We publish this week the first portion of an interesting historical *résumé* communicated to the Institution of Mechanical Engineers by Mr. Henry Deadman at their July meeting in Portsmouth, which pressure on our space has hitherto compelled us to hold over. In spite of many handsome tributes to the utility of electricity, so far as the Royal Navy is concerned, enthusiasts of the "all-by-electricity" type were dissatisfied because the author admitted that he was not over sanguine of the success of a more general application of electricity on board modern men-of-war. One speaker, as will be seen from the brief report of the discussion, which we shall reproduce from *Engineering*, thought that the whole question of electricity on board warships was unsatisfactory, and advocated the substitution of electricity for hydraulic power and compressed air.

For our own part we must confess to a decided preference for a slow but sure policy in this matter. A battleship in action will be no place for untried apparatus in inexperienced hands. At the same time there are several applications, such as hoisting shot, training guns, &c., for which electric motors would seem to be eminently adapted. Moreover, the advantages accruing from what we may term unity of mechanism are by no means negligible. If electricity can be shown to be the best for nine things out of ten and a good second in the tenth instance, by all means let it be generally adopted.

We note that Mr. Deadman talks of a search light as "evidently affording a good mark for an enemy's fire." We wonder if he has heard of the results of experiments both in this country and in France, results which tend to show that a projector, even when unprotected, enjoys a remarkable immunity from serious damage. The military authorities, however, when using search lights, place the projectors themselves out of harm's way, and direct the beam on to a reflector which, easily replaceable, is alone exposed. Do the exigencies of naval warfare altogether forbid this device?

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The modern man-of-war carries three dynamos as a rule, and one of these is always running, since a large part of the space "below" would be in absolute darkness but for electric light. So large a use has been made of this constant supply for many other purposes, that if all the dynamos became disabled in action, the vessel might as well retire from the contest. An electromagnet could be arranged so that when this unfortunate contingency arrived the flag would be automatically hauled down. Inventors please note.

With a view no doubt of maintaining the interest of its issues at a high level during the dull season, the *Electrical World* has for some weeks past opened its columns to numerous contributions on the relative merits of simple alternating, two-phase and three-phase currents, and to a discussion of the reasons which have led to the adoption of low frequencies in Germany and high frequencies in America.

Mr. Steinmetz in a communication, some extracts from which we give in our Notes columns this week, goes a long way to prove that this particular differerence of practice is due, as is generally the case, not so much to a mere desire to act differently to others, but to dissimilar conditions. In Germany it seems that the alternate current is only preferred to the continuous, either because its adoption enables a single station to supply a somewhat larger area, or because it affords some flexibility in the choice of a site for the generating centre. The mains, whether for continuous or alternating currents, are almost invariably laid only in the denser districts of thickly populated towns. Hence the possibility of sub-stations, low pressure distributing mains and those low frequencies, to which indeed the German *penchant* for slow speed direct coupled engines gives added force. In America on the other hand the alternate currents were preceded in all the denser districts by the three-wire system, and in consequence their use has been limited to the supply of straggling suburbs or scattered towns. Hence the practice of transformers in every house, to which custom the employment of high frequencies is due.

Our contemporary, *Nature*, devoted twelve amply illustrated columns to the planet Mars in last week's issue, and dwelt at considerable length upon the suggested methods of signalling to that planet, All the navies in the world are imagined to flash their search lights simultaneously; but there would remain, it says, the question of the intensity of the light. "What do electricians say is possible in this direction?" After Sir R. Ball has shown so clearly in the *Fortnightly* and in the *Graphic* that the thing is absurd, it is hardly worth while wasting space over it. Three systems have been proposed, first, to describe one of the simpler figures of Euclid on the Sahara or in Siberia, with canals, trees, or fires; the Galton system of mirrors, fifteen yards square, used as a large heliograph; and the Haweis system of handling a main switch controlling "the lights of London" during the small hours of the night. Confining ourselves to the intensity of the light, it may be remarked that taking the reflecting power of the earth to be the same as that of the moon, or according to Zöllner about 0·1, this agrees with another observation which makes the moon about three candle-power per square inch of its surface. According to L. Weber the sun gives from 500,000 to 1,000,000 candle-power per square inch. In the Galton system, therefore, there would be ample difference between the signal and its background. The Siberia system could not give a difference of more than 150 to 1. The Haweis system is, of course, out of the question, for if London were decently lighted all over, it would be an irresolvably nebulous spot, even if seen from the moon. A big search light might give 40,000 candles per square inch, and 10,000,000 candle-power could be provided without much difficulty within the space of a few square feet; at 3 candle-power per square inch the satellite of Mars gives just about a billion candle-power; astronomers may judge as to which of these two luminous objects would be the more easily visible. We will gladly enter into further calculations as soon as the inhabitants of Mars show some sign of commencing a correspondence, which, in the month of September, would be excusable.

The Hunnings Transmitter Patent.—This Patent, No. 3,647 of 1878, expires to-day.

Poplar District Board of Works.—At a recent meeting this Authority decided to apply for an Electric Lighting Order.

The Tesla Motor.—It is reported that the German patent for this motor has been acquired by the Helios Company of Ehrenfeld.

Personal.—We learn that Mr. Louis Brockman has resigned the position of Supply Superintendent to Messrs. Woodhouse and Rawson, having been appointed Manager of the Epstein Accumulator Company.

Honours.—Mr. James Sivewright, joint author with Mr. Preece of a well-known manual on Telegraphy, and at present Commissioner of Crown Lands and Public Works of Cape Colony, has been created a K.C.M.G.

Winter Sessions.—Particulars with regard to the 1892-93 Session and Evening Classes at King's College (London) and the Glasgow and West of Scotland Technical College will be found in our advertisement columns.

Oxford.—The General Purposes Committee of the Town Council have reported in favour of an additional expenditure of not exceeding £210 per annum, on a three years' contract, for lighting the central portions of the city with arc lamps.

The Western Union and Postal Telegraph Companies.—The *Western Electrician* states that there have been rumours about a proposed consolidation of the Western Union and Postal Telegraph Companies, but that little reliable information is obtainable.

Bradford.—At the last meeting of the Town Council, Alderman F. Priestman, moving the adoption of the minutes of the Gas and Electricity Supply Committee, stated that during the past half year there had been a profit on the electricity department of £387. 7s. 2d.

The City Arc Light Lanterns.—At a recent meeting of the Commissioners of Sewers it was stated in answer to several inquiries that the "frosted" glass used in the arc light lanterns was the result of a long series of experiments by Colonel Haywood, and it had been definitely decided upon.

University College, Liverpool.—Amongst the various courses of instruction to be carried on during the forthcoming Session at University College, Liverpool, we note in the recently issued prospectus, that Dr. Oliver Lodge will conduct courses on Electro-Technology and Electrical Engineering.

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Leeds.—The electric light mains are now being laid in the thoroughfares which it is proposed to light as a commencement. The erection of the central station is also progressing rapidly. There seems to be no reason to doubt that the Company will be in a position to supply electricity in November.

Fire Insurance Rules in America.—In describing a machine for painting wooden mouldings, the *Electrical Engineer* of New York says that in most of the large cities of America the boards of fire underwriters require all mouldings through which electric wires run to be coated inside and out with insulating compound.

Reading.—At a recent meeting of the Reading Town Council, it was decided not to apply for a Provisional Order, but to give consent to the grant to the Reading Electric Supply Company of a Provisional Order, if arrangements could be made for the insertion in the Order of provisions satisfactory to the council. These provisions included limitations as to price and dividends, and the right to purchase at any time.

Electric Car Accident.—A Reuter's telegram dated St. Louis, September 13th, reports a fatal accident in one of the streets of that city. As a motor car, with passenger car attached, was going down a steep gradient, the man in charge lost control over the motor and the cars rushed down the incline. Turning a curve the rear car ran off the rails and upset. One passenger was killed on the spot, while 17 others were injured.

An Electric Shunting Engine.—Messrs. Mather and Platt, of Salford, have recently constructed a heavy electric locomotive for use at some large iron works in Sweden. This locomotive is designed to work with an electromotive force of about 300 volts, and in external appearance is similar to those on the City and South London Railway. The motor is of the double armature type, the motors being connected to the axles through 10 to 1 spur gearing. An overhead wire, 16ft. from the rails, furnishes the current, the collectors consisting of an iron bar at each end of the locomotive, carried on upright pipe pillars.

Cambridge.—It is reported by the local press that the workmen engaged by the Cambridge Electric Supply Company to lay their mains buried the pipes without running pilot wires, with the result that some portions had to be dug up again. The central station has been considerably delayed by the fact that it was found necessary to go 12ft. deeper than was anticipated in order to find a suitable foundation for the chimney shaft. It is therefore probable that the current will not be available till towards the end of October. Up to the present time applications have been received by the Company for the provision of about 5,000 incandescent lights, and it is expected that a fair number of arc lamps will also be supplied.

Charterhouse Science and Art Schools and Literary Institute.—The winter session of this, one of the largest science and art schools in the United Kingdom, will commence on Saturday, September 24th, under the presidency of the Rev. Henry Swann, M.A. During the late session upwards of 1,060 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number nearly 700 presented themselves for examination, and were successful in obtaining a large number of class certificates and also a fair number of honours certificates awarded by the Science and Art Department of South Kensington. Instruction of a practical character is given in most of the sciences at a very nominal fee.

The National Telephone Company and their Wires.—At a recent meeting of the Carlisle Town Council the Town Clerk stated that in August, 1885, an agreement was entered into between the Corporation and the Telephone Company for the erection of telephone wires. The agreement was for seven years, and the period had now expired. The Surveyor said that he had written half a dozen letters to the Company asking for some plans showing the wires they had in the city, and the dates when they were put up, but he could not get any information. The Town Clerk said the Company were supposed to furnish particulars every year. It was agreed that the Town Clerk should write to the Company, informing them that if they did not carry out their agreement proceedings would be taken against them.

Thunderstorms in Spain.—According to a Reuter's telegram, dated Madrid, September 8th, during the past few weeks several thunderstorms have passed over Spain, producing as disastrous effects as the storms which swept the country at the end of spring and the beginning of summer. At Aguilar, in Cordova, the thunder is described as having been deafening, and the lightning fused about 50 metres of wire, forming part of the local electric light installation. The inhabitants, believing the intensity of the storm was increased by the electric plant, cut down some of the "mains" belonging to the Electric Light Company. In Granada much damage was caused to the crops, especially at Nerja and Torres, where the telegraph poles were blown down. A gentleman was killed by lightning near the station of Campanillas. At Ecija the tower of the Church of Santa Barbara was struck by lightning, and the building has since been closed as being dangerous. At Fuentalama a woman and her daughter were killed by lightning, and a boy was injured.

The Electrical Deposition of Soot.—During the recent meeting of the British Association in Edinburgh, the Chemical Section paid a visit to the oil and printing ink works of Messrs. A. B. Fleming and Co. A large shed in the works is devoted to the manufacture of printer's black. This is accomplished by allowing a thick heavy oil to flow through a pipe and drip slowly into a large closed chamber. The oil here burns slowly, producing a dense volume of intensely black soot, which is removed from time to time, and is used exclusively for the black printing inks. The deposition of the dense black smoke in these close chambers is very slow. The smoke particles, however, gradually coalesce and fall to the bottom of the chamber as black soot, but even when the depositing chambers are large the yield of printer's black is small. Mr. Robert Irvine, the chemical director of the firm, has, says *Industries*, devoted some time towards devising a means for hastening this deposition, and has found that, by adopting Dr. Lodge's suggestion of a series of electrified metal points placed within the chamber, the formation of the deposit is much accelerated. The process has not, however, so far been adopted on a large scale, owing to considerations of cost.

Electric Lighting in Chelsea.—The following extract from the report of the surveyor of the Chelsea Vestry for the year 1891-92 will be of interest:—"At the end of July the Vestry appointed me an inspector under the Electric Lighting Acts, so as to empower me to examine the records of pressure, &c., kept by the Electric Lighting Companies. The Cadogan Electric Lighting Company not yet having complied with their Act as regards a money deposit, the Board of Trade have not served them with the usual regulations as to safety and supply, so that the only Company keeping records which the Vestry's inspector can examine is the Chelsea Electricity Supply Company. From time to time I have inspected the records kept by this Company, and find that the pressure recorded by their instruments is always above 100 volts—it usually being about an average of 103 volts—except on one or two occasions when alterations were being made to the engines. I consider that their system shows very satisfactory results, and I am of opinion that they keep well within the limits laid down in the Board of Trade's regulations.

Houses Lighted by Electricity.

The number of houses lighted by electricity in Chelsea was:—

	1889-90.	1890-91.	1891-92.
Chelsea Electricity Supply Company ...	113	215	312
Cadogan Electric Light Company.....	25	16	18
London Electric Supply Corporation ..	1	2	2
	139	233	332

Mechanically Exhausted Incandescent Lamps.—There appears, says *Industries*, to be a small revolution going on in American lamp manufacture, and the mechanical pump threatens to displace those of the Sprengel and Geissler type. It seems strange that it should only be found out now that mechanical pumps can give sufficiently good vacua; and it is also curious that these pumps should give the vacua claimed for them. Most of the mechanical pumps described comprise little in advance of the various kinds that have been in use in this country and on the Continent for other purposes requiring good vacua—such as making ice by the evaporation of water—but

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until recently no one thought of using such pumps for the final exhaustion of incandescent lamps. On the one hand a great deal of nonsense has been talked about the extreme perfection of the vacuum produced by mercury pumps, and the durability of lamps made with such vacua; but, on the other hand, some of the statements of the advocates of mechanical pumps are difficult to admit. For instance, a favourite claim is that a residual vacuum of hydrocarbon is good, because it is absorbed by the hot carbon, so that the vapours from the oil used to lubricate the pump do not destroy the vacuum. It is needless to remark that hot carbon decomposes hydrocarbon vapour, and leaves a greater volume of hydrogen. Though this may be the case, it may also be true that a mechanical pump can produce a sufficiently good vacuum. If this be so, it will be a matter of great convenience, for though there is not much room for reduction of expense in the exhaustion of lamps, every farthing will be important as soon as competition becomes keen.

Electric Traction in Montreal.—A short time ago the Montreal City Council, says the *Electrical Engineer* of New York, invited tenders for the privilege of operating street railways by electricity in that city, in response to which tenders were received from several syndicates representing American and Canadian capitalists. After many meetings of the council and much virulent discussion of the merits of the different tenders, the contract was awarded to the Montreal Street Railway Company on July 19th. This Company, who at present operate the horse-railway system in the city, will now have the exclusive right to propel cars by electricity on the principal thoroughfares for the next 30 years. New lines and old lines are all to be laid with English grooved rails. As for nearly four months of the year the Montreal streets are covered with snow, often to a depth of two or three feet, the operation of the cars in winter has received careful consideration. In order to enable the electric cars to run all winter, the snow will be removed from the entire roadway of the streets on their routes, leaving a layer of sufficient depth on either side of the track for sleighing, and the tracks will then be kept clear by the use of sweepers and ploughs. The city and Company are to share the expense of removing the snow. At present the horse cars run for about eight months of the year, and during the remaining time sleighs or stages are used, the stages being used when the streets are not in good condition for sleighing. The prospect of having electric cars that will run all winter and give a rapid and reliable service in spite of the snow is said to give great satisfaction to the inhabitants of Montreal. Material, including 80 cars, has already been ordered. The cars are to be equipped with two 25 H.P. single reduction motors each, in order to have ample power for ascending grades. These motors have been ordered of the Royal Electric Company. For the present, this company (the Royal) will furnish the power for running the cars from their lighting station, and are building eight 250 H.P. generators for this purpose. The poles of the Bell Telephone Company and those of the Royal Electric Company are being used for the suspension of the trolley wire as far as possible.

The Frequency of Alternate and Polyphase Current Systems.—The reasons why on the Continent a comparatively low frequency of 40 to 50 periods per second has been adopted, and here exclusively frequencies of 120 to 150 periods are used, are, writes Mr. Chas. Steinmetz in the *Electrical World*, entirely out of the choice of the motor designer, because based upon the differences in the very conditions of social life here and there. On the Continent, continues Mr. Steinmetz, when a city intends to introduce the electric light—first certainly only for the denser populated and better situated parts—a committee of city officials and business men is elected; this committee again elects a committee of experts—university professors—and after meeting for a couple of years and filling the vacancies caused by the death of members, the committees get so far as to ask for bids from the electric supply companies. After careful study of all the propositions, for continuous, alternating, &c., current systems, naturally the committee know still less than before which system is the best, and consequently some more committees are elected, &c. Now, the consequence of this method is, that alternate and continuous current systems are co-ordinate and competitors, both supplying only denser populated districts, and where the alternating system is chosen it is used only because it allows the supply of a larger area from one central station, and the location of the central station in the suburbs. But the consumers living near together, a secondary network can reach them, and consequently the transformer is used as secondary or sub-station, feeding into a secondary network which supplies many consumers. Large units of transformers are used then, and they are cut out or cut in according to the fluctuations of load. Because of the larger size of transformers, they can be worked very economically with low frequency, and consequently low frequency is used on the Continent, the more as direct coupled slow-speed engines are preferred. In the United States the alternating current, entering the field, found the denser populated city districts occupied already by continuous-current systems, which distributed light and power, and in this latter respect were superior to the alternating systems of those days. But in the suburbs, in smaller cities and scattered districts, the alternating current found a field where the continous-current was entirely out of competition. In consequence of this the European system of transformer sub station and secondary distributing mains is not applicable, and the individual consumers can be reached only by the primary mains, and have to be provided with separate transformers of smaller size. In this way the high frequency employed throughout in this country is necessitated by the direct primary distribution to the customers.

Fireproof Insulation.—Fires from electric wires laid in metal conduits are, says Mr. Reginald A. Fessenden in the *Electrical World*, an impossibility, and fires from switch and fuse boards are simply a question of proper design. There is, however, always a danger from the use of flexible cords or pendent lamps, especially when hung near curtains or tapestry. The only safety in this case is in the use of a fire and water proof, flexible insulation. The following recipe, which it was actually proposed by Mr. Edison to use commercially, is then given by Mr. Fessenden:—100 parts of linseed oil, 50 parts strained Mexican asphalte, and 10 parts zinc chloride are boiled down at 300°C., till all the zinc chloride has combined with the other materials. The mixture is then put in a sort of ice-cream freezer, and stirred up while 50 parts of antimony pentachloride are run in, the mixture being kept cool by a water jacket. After stirring for an hour, boiling water is run in, and the mixture heated by passing steam into the water jacket. After mixing for another hour all the free acid will be found to be washed out, and the material is then ready to be applied to the wire. This gives a dark product, however, and is, moreover, more expensive than the product obtained by simply passing chlorine into a hydrocarbon, such as paraffin, and then washing. In this case we get a substance very much like paraffin, but heavier, more easily acted on by alkalies, uninflammable, which may be held in a Bunsen flame till it is reduced to charcoal, without showing more signs of ignition than a piece of marble. Several hundred feet of wire coated only with these substances were coiled up in tubes of salt water. After the lapse of several months the insulation was still high, while samples three years old show no signs of deterioration. The practical method of obtaining these substances is very simple. The asphalte or paraffin is heated till it melts, and chlorine gas is passed into it. Of every two atoms of chlorine that goes in, one unites itself with an atom of hydrogen and passes off, the other takes the place of the hydrogen atom. This goes on till enough of the hydrogen has been replaced by chlorine to render the substance non-inflammable. The substance is then taken out, and, still kept in the melted state, is washed with boiling water in a machine like an ice-cream freezer, till all the acid remaining has been thoroughly washed away. It is then allowed to cool, and is masticated to remove the remaining water, when it is ready for use. It may be mentioned, adds Mr. Fessenden, that the gases given off from these materials when heated to such a temperature as to cause decomposition will not support combustion. For instance, if wood shavings are partly covered with the composition, and placed in a box and lit, so soon as the greyish decomposition vapours begin to come off freely the fire is put out.

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ELECTROMAGNETIC THEORY.—XXXVI.

BY OLIVER HEAVISIDE.

(*Continued from page 479.*)

§ 163. We see from the preceding that when it is the electric force that is given in a dielectric there is no difficulty in finding the displacement; and conversely, when the displacement is given, the electric force similarly becomes known through the values of the principal permittivities. Suppose, however, that the data do not include a knowledge of either the electric force or the displacement, both of which have to be found to suit other data. It is then sufficient to find either, the linear connection settling the other. Thus to take an explicit case which has, for a reason which will appear, a special interest, suppose the dielectric medium to have uniform permittivity transverse to the axis of **k**, but to be differently permittive to displacement parallel to this axis. Further, put a point-charge q at the origin, and enquire what is the equilibrium distribution of displacement.

The statement that there is a charge q at the origin means nothing more than that displacement diverges or emanates from that place, to the integral amount q. We also understand, of course, that the displacement has no divergence anywhere else. But the manner of emanation is, so far, left quite arbitrary. Certain general results may, however, be readily arrived at. To begin with, if the medium is isotropic, the emanation of the displacement must not favour one direction more than another, from which it follows that the displacement at distance r from the source is spread uniformly over the area $4\pi r^2$, so that $q/4\pi r^2$ expresses its density. Now if we alter the permittivity to displacement parallel to **k** only, we favour displacement in that direction if the permittivity is increased, at the expense of the transverse displacement, because the total amount, which measures the strength of the source, is the same. Conversely, if we reduce the permittivity parallel to **k**, we favour the transverse displacement. The lines of displacement, originally spread equably, therefore separate themselves about the **k** axis (both ways), and concentrate themselves transversely, or about the equatorial plane, the plane passing through the charge which is cut by the **k** axis perpendicularly.

If we carry this process so far as to reduce the permittivity along **k** to zero, there can be no displacement at all parallel to **k**, so that the displacement must be entirely confined to the equatorial plane itself. In this plane it spreads equably from the source, because of the transverse isotropy assumed at the beginning. The amount q therefore spreads uniformly over the circle of circumference $2\pi r$ in the displacement sheet, so that the density (linear) is now $q/2\pi r$. The law of the inverse square of the distance has been replaced by the law of the inverse distance, with confinement to a single plane, however.

Next, if we introduce planar eolotropy, say by reducing the permittivity in direction **j**, we cause the displacement in the sheet to concentrate itself about the **i** axis, at the expense of the displacement parallel to **j**. Finally, if we abolish altogether the permittivity parallel to **j**, the whole of the displacement will be confined to the **i** axis, half going one way and half the other.

We may go further by introducing heterogeneity. Thus, reduce the permittivity on one side of the equatorial plane. The effect will be to favour displacement on the other side; and, in the limit, when the permittivity is altogether abolished on the first side, the whole of the displacement goes unilaterally along the **k** axis on the other side.

In the case of the planar distribution of displacement, the surface-density is infinite, but the linear-density is finite, except at the source. We may, however, spread out the source along a finite straight line (part of the **k** axis) when the displacement will simultaneously spread out in parallel sheets, giving a finite surface-density. Similarly, in the case of the linear distribution of displacement along the **i** axis, we may spread out the source upon a portion of the **j**, **k** plane, when the former line of displacement will become a tube, with finite surface-density of displacement inside it.

In the above manner, therefore, we obtain a general knowledge of results without mathematics. Except, however, in the extreme cases of spherical isotropy, of planar isotropy with zero permittivity perpendicular to the plane, and of purely linear displacement due to the vanishing of the transverse permittivity, and other extreme cases that may be named, we do not obtain an exact knowledge of the results, except in one respect, that the total displacement must always be the same. Return, therefore, to the case of initial isotropy upset by changed permittivity parallel to the **k** axis, or, if need be, with three different principal permittivities, so that the displacement is

$$\mathbf{D} = \mathbf{i}.c_1\mathrm{F}_1 + \mathbf{j}.c_2\mathrm{F}_2 + \mathbf{k}.c_3\mathrm{F}_3 = c\mathbf{F}, \quad . \quad . \quad . \quad (32)$$

if **F** be the electric force. We know that in the state of equilibrium, there must be no voltage in any circuit, or the curl of **F** must be zero, so that **F** must be the slope $-\nabla\mathrm{P}$ of a scalar P, the potential. Furthermore, the divergence of **D** is the electrification-density ρ. Uniting, then, these results, we obtain

$$\mathrm{div}(-c\nabla\mathrm{P}) = \rho, \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

or

$$(c_1\nabla_1^2 + c_2\nabla_2^2 + c_3\nabla_3^2)\mathrm{P} = -\rho, \quad . \quad . \quad . \quad (34)$$

which is the characteristic of P when referred to the principal axes. Now when there is a point-source at the origin, and the three c's are equal, we know that the potential is $q/4\pi rc$ at distance r. From this, remembering that r^2 is the sum of the squares of the components of **r**, it is easy to see that the potential in the case of eolotropy is

$$\mathrm{P} = \frac{fq/4\pi}{(x^2/c_1 + y^2/c_2 + z^2/c_3)^{\frac{1}{2}}} = \frac{fq/4\pi}{(\mathbf{r}c^{-1}\mathbf{r})^{\frac{1}{2}}}, \quad . \quad . \quad (35)$$

where f is some constant, because this expression (35) satisfies (34) with $\rho = 0$, that is to say, away from the source.

The constant f may be evaluated by calculating the displacement passing through the surface of any sphere $r =$ constant, according to (35), and equating it to q. The result is $f = (c_1c_2c_3)^{-\frac{1}{2}}$. The complete potential in the eolotropic medium due to the point-source q at the origin is therefore

$$\mathrm{P} = \frac{q/4\pi}{(c_1c_2c_3)^{\frac{1}{2}}(\mathbf{r}c^{-1}\mathbf{r})^{\frac{1}{2}}}. \quad . \quad . \quad . \quad . \quad . \quad (36)$$

The equipotential surfaces are therefore ellipsoids centred at the charge, the equation of any one being

$$\mathbf{r}c^{-1}\mathbf{r} = \frac{x^2}{c_1} + \frac{y^2}{c_2} + \frac{z^2}{c_3} = \text{constant}, \quad . \quad . \quad . \quad (37)$$

so that the lengths of the principal axes are proportional to the square roots of the principal permittivities. The lines of electric force cut through the equipotential surfaces at right angles. But the lines of displacement do not do so, on account of the eolotropy. To find their nature, first derive the electric force from the potential by differentiation. Then (36) gives

$$\mathbf{F} = \frac{(q/4\pi)c^{-1}\mathbf{r}}{(c_1c_2c_3)^{\frac{1}{2}}(\mathbf{r}c^{-1}\mathbf{r})^{\frac{3}{2}}}, \quad . \quad . \quad . \quad . \quad (38)$$

and the displacement is obtained by operating by c on this, which cancels the c^{-1}, and gives

$$\mathbf{D} = \frac{(q/4\pi)\mathbf{r}}{(c_1c_2c_3)^{\frac{1}{2}}(\mathbf{r}c^{-1}\mathbf{r})^{\frac{3}{2}}}. \quad . \quad . \quad . \quad . \quad (39)$$

The displacement is therefore radial, or parallel to **r** itself. That is, the lines of displacement remain straight, only altering their distribution as the medium is made eolotropic.

Observe, in passing, that the scalar product **FD** varies as P^4; that is, the density of the energy varies as the fourth power of the potential. Also note that **Fr** is proportional to P; that is, the radial component of **F**, or the component parallel to the displacement, varies as P/r.

If we select any pair of equipotential surfaces between which the electric force and displacement are given by (38), (39), we may, if we please, do away with the rest of the electric field. That is, we may let the displacement and electric force terminate abruptly upon the two ellipsoidal surfaces. What is left will still be in equilibrium. For the voltage remains zero in every circuit possible. This is obviously true between the surfaces, because no change has been made there. It is also true in any circuit beyond the surfaces, because of the absence of electric force. And lastly, it is true for any circuit partly within and partly beyond the region of electric force, because the electric force is perpendicular to the surface. So the electric

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field is self-contained. The electrification is on the surfaces, where the normal component of the displacement measures the surface-density. That is, there is a total electrification q on the inner and $-q$ on the outer surface. The elastance of the condenser, or "leyden," to use Lord Rayleigh's word, formed by the two surfaces, is the ratio of the voltage between them to q. That is, the coefficient of q in (36) is the elastance between any equipotential surface and the one at infinity.

In thus abolishing the electric field beyond the limited region selected, we may at the same time change the nature of the medium, making it isotropic, for example, or conducting, &c. Any change is permissible that does not introduce sources that will disturb the equilibrium of the electric field between the equipotential surfaces.

Starting from isotropy, when the equipotential surface is a sphere, if we keep $c_1 = c_2$ constant, and reduce c_3, the sphere will become an oblate spheroid, like the earth (and other bodies)—flattened at the poles. Let the common value of c_1 and c_2 be denoted by c_0, then the potential due to the central charge q is

$$\mathrm{P} = \frac{q/4\pi}{c_0 c_3^{\frac{1}{2}}(x^2/c_0 + y^2/c_0 + z^2/c_3)^{\frac{1}{2}}}, \quad . \quad . \quad . \quad (40)$$

and the displacement and electric force are given by

$$c\mathbf{F} = \mathbf{D} = \frac{(q/4\pi)\mathbf{r}}{c_0 c_3^{\frac{1}{2}}(x^2/c_0 + y^2/c_0 + z^2/c_3)^{\frac{3}{2}}}. \quad . \quad . \quad (41)$$

As c_3 is continuously reduced the oblate spheroid of equilibrium becomes flattened more and more, and is finally, when $c_3 = 0$, reduced to a circular disc. The displacement is now entirely in the equatorial plane, so that if we terminate the displacement at distance r from the centre, we obtain a circular line of electrification (that is, on the edge of the disc). We may have the displacement going from the central charge to an equal negative charge spread over the circle, or from one circle to another in the same plane; and so on.

Similarly, when c_1 and c_2 are unequal, but $c_3 = 0$, the circular disc is replaced by an elliptical disc. But, without introducing transverse eolotropy, we see that the abolition of the permittivity in a certain direction has the effect of converting the usual tridimensional solutions relating to an isotropic medium to bidimensional solutions, in which the displacement due to sources situated in any plane perpendicular to the axis of symmetry is also in that plane. We may have any number of such planar distributions side by side, with the axis of symmetry running through them. But they are quite independent of one another. If we restore the permittivity parallel to the axis of symmetry, the displacement will usually spread out to suit tridimensional isotropy. The exception is when every plane perpendicular to the axis has identically similar sources, similarly situated. Then the restoration of the permittivity will produce no change.

§ 164. Let us now pass to what is, at first sight, an entirely different problem, but which involves essentially the same mathematics. As before, let there be a point-source of displacement at the origin, but let the dielectric medium be homogeneous and fully isotropic. The displacement will be radially distributed, without bias one way or another. Now, keeping the charge fixed in space, imagine the medium to move steadily from right to left past the charge. How will this affect the displacement?

If we desire the solution expressing how the displacement changes from its initial distribution, as the medium is brought from rest into steady motion, we can obtain it by going the right way to work. But it is complex, and will, therefore, not be given here, especially as it is not intelligible without close study. But if we only wish to know the finally-assumed distribution of displacement when the initial irregularities have subsided, we may obtain and express the result in a comparatively simple manner. Thus, to begin from the foundation, we have the two fundamental circuital laws,

$$\mathrm{curl}\,(\mathbf{H} - \mathbf{h}) = cp\mathbf{E} + \rho\mathbf{u}, \quad . \quad . \quad . \quad . \quad (42)$$

$$\mathrm{curl}\,(\mathbf{e} - \mathbf{E}) = \mu p\mathbf{H}, \quad . \quad . \quad . \quad . \quad . \quad (43)$$

where $\mathbf{E}$ and $\mathbf{H}$ are the electric and magnetic forces, μ and c the inductivity and permittivity, ρ the density of electrification, supposed to have velocity $\mathbf{u}$; and $\mathbf{e}$, $\mathbf{h}$ are the motional electric and magnetic forces given by

$$\mathbf{e} = \mathrm{V}\mathbf{w}\mathbf{B}, \qquad \mathbf{h} = \mathrm{V}\mathbf{D}\mathbf{w}, \quad . \quad . \quad . \quad (44)$$

$\mathbf{B}$ and $\mathbf{D}$ being the induction and displacement, and $\mathbf{w}$ the velocity of the medium. (See equations (1), (2), or (3), (4), § 66, and equations (5), (6), § 44, for the motional forces. Also §§ 33 to 70 generally.)

Now in our present case, $\mathbf{E}$ and $\mathbf{H}$ are steady, and the electrification is at rest. The right sides of (42), (43) are therefore zero, which is a great simplification. By (42) and the second of (44) we obtain

$$\mathrm{curl}\,\mathbf{H} = \mathrm{curl}\,\mathbf{h} = \mathrm{curl}\,\mathrm{V}\mathbf{D}\mathbf{w}. \quad . \quad . \quad . \quad (45)$$

But $\mathbf{B}$ is circuital, and therefore so is $\mathbf{H}$. It follows that

$$\mathbf{H} = \mathrm{V}\mathbf{u}\mathbf{D}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (46)$$

if we substitute $-\mathbf{u}$ for $\mathbf{w}$, for future convenience. This gives $\mathbf{H}$ explicitly in terms of the displacement, when that is known, so we have no further trouble with the magnetic force.

To find the displacement, (43) gives, along with the first of (44),

$$\mathrm{curl}\,(\mathbf{E} + \mathrm{V}\mathbf{u}\mathbf{B}) = 0, \quad . \quad . \quad . \quad . \quad (47)$$

or say, $\mathrm{curl}\,\mathbf{f} = 0$, if $\mathbf{f} = \mathbf{E} + \mathrm{V}\mathbf{u}\mathbf{B}$. . . . (48)

Now put the value of $\mathbf{B}$ in $\mathbf{f}$ by (46), thus,

$$\mathbf{f} = \mathbf{E} + \mu c\mathrm{V}\mathbf{u}\mathrm{V}\mathbf{u}\mathbf{E} = \mathbf{E} + \frac{u^2}{v^2}\mathrm{V}\mathbf{k}\mathrm{V}\mathbf{k}\mathbf{E}, \quad . \quad . \quad (49)$$

since $\mu c v^2 = 1$, v being the speed of propagation of disturbances, and u the tensor of $\mathbf{u}$, supposed to be parallel to $\mathbf{k}$.

Expanding by the fundamental formula (52), § 114, we obtain

$$\mathbf{f} = \mathbf{E} + \frac{u^2}{v^2}(\mathbf{k}.\mathrm{E}_3 - \mathbf{E})$$

$$= (1 - \frac{u^2}{v^2})\mathbf{i}\mathrm{E}_1 + (1 - \frac{u^2}{v^2})\mathbf{j}\mathrm{E}_2 + \mathbf{k}\mathrm{E}_3. \quad . \quad . \quad (50)$$

Now let $\mathbf{f} = (1 - u^2/v^2)\mathbf{F}$. Insert in (50), and divide by $(1 - u^2/v^2)$. The result is

$$\mathbf{F} = \mathbf{i}\mathrm{E}_1 + \mathbf{j}\mathrm{E}_2 + \frac{\mathbf{k}\mathrm{E}_3}{1 - u^2/v^2}. \quad . \quad . \quad . \quad . \quad (51)$$

This vector $\mathbf{F}$ must also have no curl. Therefore, if P is the potential whose slope is $\mathbf{F}$, we have

$$\mathrm{E}_1 = -\frac{d\mathrm{P}}{dx}, \quad \mathrm{E}_2 = -\frac{d\mathrm{P}}{dy}, \quad \mathrm{E}_3 = -(1 - \frac{u^2}{v^2})\frac{d\mathrm{P}}{dz}, \quad (52)$$

and the components of displacement are given by

$$\mathrm{D}_1 = -c_1\frac{d\mathrm{P}}{dx}, \quad \mathrm{D}_2 = -c_2\frac{d\mathrm{P}}{dy}, \quad \mathrm{D}_3 = -c_3\frac{d\mathrm{P}}{dz}, \quad . \quad (53)$$

if $c_1 = c_2 = c$, and $c_3 = c(1 - u^2/v^2)$, . . (54)

Now observe that (53) express the displacement in terms of the electric force in an eolotropic medium at rest, whose principal permittivities are given by (54), when P represents the electrostatic potential. Our present problem of a moving isotropic medium is therefore reduced to one relating to a stationary eolotropic medium. Thus, to state the comparison fairly, when the isotropic medium moves bodily past a stationary charge, the displacement distribution becomes identically the same as if the medium were at rest, but had its permittivity in the direction of motion reduced from c to $c(1 - u^2/v^2)$. The solution is therefore given by (40), (41) in § 163, by taking $c_0 = c$, and c_3 as in (54). The displacement concentrates itself about the equatorial plane, or plane through the charge perpendicular to the axis of motion in the one problem, or axis of reduced permittivity in the other. In the limit, when the speed of motion reaches v, the speed of light, the displacement is wholly planar, as in the eolotropic case when the permittivity c_3 vanishes.

Observe, in (52), that the square of u occurs. It does not matter, therefore, which way the motion takes place, so far as the displacement is concerned. But it makes a great difference in the magnetic force which accompanies the lateral concentration of the displacement. Being given by (46), we see that $\mathbf{H}$ reverses itself when the direction of motion is reversed.

It should be carefully noted that P, which is the electrostatic potential in the eolotropic stationary medium, is not the electrostatic potential in the moving medium, although it is the same

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function precisely. In the eolotropic medium its slope is the electric force **F**. In the moving medium its slope is the same force **F**, but this is no longer the electric force, which is **E** instead, obtained from **F** by (51) or (52). Again, whilst the displacement and electric force are not parallel in the stationary eolotropic medium; on the other hand, in the moving medium they are parallel, because the medium is isotropic. To complete the differences, there is no magnetic force in the eolotropic case, but there is in the moving medium, and it is its existence which allows the parallel to exist as regards the identical distributions of displacement.

Instead of moving the medium past a fixed charge, we may fix the medium, and move the charge through it the reverse way at the same speed. This is why we put $\mathbf{w} = -\mathbf{u}$. The above results apply when the charge q moves with velocity $\mathbf{u}$ through the stationary medium. But it is necessary now to travel with the charge in order to see the same results, because the origin is taken at the charge, and it is now in motion. The preliminary mathematics is therefore less easy.

The above theory of convection currents and the eolotropic comparison I have given before. I have now to add a somewhat important correction. For the opportunity of making this correction I am indebted to Mr. G. F. C. Searle, of Cambridge, who has been at the trouble of working his way through my former calculations. Whilst fully confirming my results for a point-charge, and therefore all results obtained therefrom by integration, he has recently (in a private communication) cast doubt upon the validity of the extension of the solution to the case of a moving charged conducting sphere, and has asked the plain question (in effect):—What justification is there for taking distributions of displacement calculated in the above manner, and cutting them short by surfaces to which the displacement is perpendicular, which surfaces are then made equilibrium surfaces? For example, in the solution for a point-charge, I assumed that the solution was the same for a charged sphere, because the lines of electric force met it perpendicularly. On examination, however, I find that there is no justification for this process. The electric force should not be normal to a surface of equilibrium, exceptions excepted.

The true boundary condition for equilibrium, however, needs no fresh investigation, being implicitly contained in the above. In the stationary case of eolotropy, the vector **F** must have no curl, and since it is the electric force, it is the same as saying that there must be no voltage in any circuit, so that **F** must be normal to an equilibrium surface. Now, in the problem of a moving medium with charge fixed the same condition formally obtains, viz., that **F** shall have no curl. But as it is not the electric force **E**, it is clear that the displacement (which is parallel to **E**) cannot be perpendicular to an equilibrium surface. The voltage calculated by the fictitious electric force **F** must come to zero in every circuit. The boundary condition is, therefore, that **F** is perpendicular to an equilibrium surface. That is, $P = \text{constant}$ is the equation to a surface of equilibrium (no longer equipotential in the electrostatic sense), where P is, however, the same function as in the eolotropic stationary problem of electrostatics.

Therefore, by § 163, we see that the sphere of equilibrium when the medium (isotropic) is stationary, becomes an oblate spheroid when the medium is set into a state of steady motion, the shorter axis being parallel to the line of motion. In the limit, when the speed is v, the spheroid is flattened to a circular disc, on whose edge only is the electrification.

This applies when the whole dielectric medium is moving past a fixed spheroidal surface of electrification. It equally applies when the electrification moves the other way through a fixed medium. There will be no electric force in its interior. We may therefore fill it up with conducting matter, provided we do not interfere with the free motion of the external medium through it in the one case, or with the rest of the external medium when the conductor moves through it. But in the limiting case of motion at the speed of light, when only a single circular line of electrification is concerned, it would seem to be immaterial whether the conductor be a flat disc or a sphere, subject to the reservation of the last sentence.

Whether it is possible to move matter through the ether without disturbing it forms an entirely different question, to which no definite answer can be given at present. We can, in any case, fall back upon the more abstract theory of electrification moving through the ether, without having conductors to interfere.

(*To be continued.*)

ON THE MEASUREMENT OF THE MAGNETIC PROPERTIES OF IRON.*

BY THOMAS GRAY, B.SC., F.R.S.E.

This Paper gives the method of experiment and results obtained in some investigations on the time-rate of rise of current in a circuit having large electro-magnetic inertia. The experiments were made on a circuit containing the coils of a large electro-magnet having laminated cores and pole pieces. The mean length of the iron circuit was about 250cm. and its cross section 320sq. cm. The magnetising coil had 3,840 turns, when all joined in series, and a resistance of 10·4 ohms. The coils were so arranged that they could be joined in a variety of ways so as to vary the resistance, inductive coefficient, &c., and also to allow the magnet to be used either as an open or a closed circuit transformer. The E.M.F. used in the experiments was obtained from a storage battery, and the method of experiment was to trace the curve, giving the relation of current to time, on a chronograph sheet.

One set of experiments shows the effect of varying the impressed E.M.F. on the time required for the current to attain any given percentage of its maximum strength. The results show that for any particular percentage there is always a particular E.M.F. which takes maximum time. Thus for the circuit under consideration, and with successive repetitions of the current in the same direction, it takes longer time for the current produced by an impressed E.M.F. of 4 volts to reach 95 per cent. of its maximum than it takes for the current produced by either 3 or 5 volts to reach 95 per cent. of their maximum. The results show also that, within considerable limits, the time required for the current to become uniform is on the whole nearly inversely proportional to the impressed E.M.F., and that for moderate values of the E.M.F. the time may be very great; when the E.M.F. was 2 volts, and the current sent in such a direction as to reverse the magnetism left in the magnet by a previous current of the same strength, the time required for the current to establish itself was over three minutes. The difference of time required for repetition and for reversal of previous magnetisation was also very marked when the iron circuit was closed. The results show that great errors may arise by the use of ballistic methods of experiment, especially when weak currents are used, and that for testing resistances of circuits containing electro-magnets, a saving of time may be obtained by using a battery of considerable E.M.F.

Another set of experiments gives the effect of successive reversals of the impressed E.M.F. at sufficient intervals apart to allow the magnetisation to be established in each direction before reversal began. In this set also the effect of cutting out the battery and leaving the magnet circuit closed is illustrated, showing that several minutes may be required for the magnet to lose its magnetism by dissipation of energy in the magnetising coil. The effect on these cycles of leaving an air space in the iron circuit is also illustrated. It is shown that a comparatively small air space nearly eliminates the residual magnetism and diminishes considerably the rate of variation of the coefficient of induction and the dissipation of energy in the magnet.

Several cycles are shown for the magnet used as a transformer with different loads on the secondary. The results give evidence that there is less energy dissipated in the iron the greater the load on the secondary of the transformer.

Some experiments are also quoted which go to show that the dissipation of energy due to magnetic retentiveness (magnetic hysteresis) is simply proportional to the total induction produced when the measurements are made by kinetic methods. Reference is made to the recent experiments of Alexander Siemens and others which seem to confirm this view.

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* Abstract of a Paper read before the Royal Society.

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ELECTRICITY AND MEDICINE.

All progress, it may be said, has from time to time been impeded by unworthy work; and the progress of science has suffered as much as that of any other branch of learning, and this not always in its applications, but even in research itself. Astronomy, which has been deservedly called the noblest of the sciences, lapsed through astrology into the most impudent charlatanry, which survives to this day in the silliest form in certain weekly journals. The whole of chemistry was at one period swamped by a flood of delusion, that remarkable quest of the alchemists, which saw a large band of workers whom we must call scientific men, numbering, perhaps, Sir ISAAC NEWTON among them, concentrating all their powers, in their own fashion, upon the direct production of gold; the aim which, although, it may be said to underlie all commercial activity, science in its best moments is proud to disclaim. Mechanical science has its Keely motors and Marchant engines; and worthless water motors are being pushed to-day, whether in ignorance or something worse we cannot tell. Electrical science may be justly ashamed of what has been done, and what will probably continue to be done with primary batteries for electric lighting, while to many medical men the very name of elec-

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tricity is abhorrent. Not only is electric light supposed to injure eyesight, and telegrams to add to the worries of life, but by electricity presumptious laymen have dared to attempt cures, and in their unrecognised methods have even repudiated either assistance or sympathy from qualified practitioners. The general public are little aware of the debt which they owe to the professional rules and etiquette which control the doctor, the architect, the barrister, and other professional men. Their rules, self-imposed, and observed not indeed to the letter, for they are unwritten, but kept with most conscientious strictness, are the safest protection both of themselves and of their clients.

Two hundred years ago electricity was first employed in medicine, and though quackery was rampant then as now, electrical treatment, being unknown, was at least free from reproach. Medical methods have been, and still are largely empirical, and the remarkable effect of electrical discharges upon both nerve and muscle suggested that some curative properties might be expected from an agent which exhibited such powerful physiological effects. But no rational or systematic use was made of it. Some accidental cures seem to have been effected, and the very ignorance of those who employed electricity, encouraged quacks to seize upon electrica treatment as possessing the valuable qualities of mystery and comparative harmlessness. A few workers on the Continent had sufficient courage to investigate a branch of medical science which had fallen into disrepute, and about forty years ago Du Bois Reymond and one or two other physiologists made real advance in purely scientific investigation, while Erb and others studied the use of electricity in diagnosis and curative effects. In this country medical electricity still remained under a cloud. With the exception of the late Dr. Steavenson and Dr. Stone hardly a single doctor in this country dared ignore the taboo which had been placed upon it by the English medical school.

Erring, perhaps, on the safe side, and with as strong a conservatism as that which forbad them to use certain drugs merely because homœopathists set a high value upon them, they have left it severely alone. One or two makers of induction coils, being unqualified men, have done something to strengthen this prejudice, especially as they claimed success, and during the last few years an honest attempt to apply electrical treatment with care and intelligence has retarded rather than assisted the progress of the subject, because several professional rules were broken, the requirements of proper qualification were not attended to, and advertising was employed, not only directly, but by the equally unprofessional action of communicating articles and papers to non-medical journals and scientific societies. So sensitive are English medical men in this matter that we shrink from devoting much attention to electrotherapeutics in these columns. The discussion of the curative properties of a new drug would be out of place in a chemical journal, though an account of its preparation might not; and we believe that the true interests of medical electricity will be best served if we confine ourselves to any matters of electro-physiology that may arise, to description of appliances, and to the review of books which are sent us. Meanwhile we believe that steady progress is being made on strictly professional lines both in hospital practice and in private treatment. All that is done in this way goes to the stock of orthodox medical science. Cases of positive cure will be received with caution and new hypotheses with hesitation, and the present prejudice and apathy will doubtless continue well into the next century, but there are ample grounds for believing that in proper hands there is a great future for the use of electricity both for diagnosis and for cure.

REVIEWS.

Medical Electricity: a Practical Handbook for Students and Practitioners. By W. E. Steavenson, M.D., and H. Lewis Jones, M.A., M.D. (London: H. K. Lewis, 1892.)

The late Dr. Steavenson who was in charge of the electrical department at St. Bartholomew's Hospital, left in the form of manuscript and a large mass of notes the material for a work upon medical electricity. These were left at his death in so incomplete a state, that, while the plan of the book has been followed, much of his valuable experience has unfortunately been lost. Dr. Lewis Jones, the present medical officer in charge of the now well-established electrical department at "Barts," has completed the work in a most satisfactory manner.

About one-fifth of the book, devoted to the elementary physics of the subject, and written in collaboration with Mr. H. M. Elder, one of the secretaries of the Physical Society, is in itself a useful little text-book of electricity, and is commendably free from lecture-room antiquities and from lists of examination questions which generally accompany electrical literature of this kind. This part of the book forms a thoroughly sound basis for the medical student or practitioner, and contains numerous references to standard text books for those who wish to push their studies further. A brief, almost too brief, sketch of the subject of electrolysis is given, and enough is said upon electro-magnetic induction to give an elementary account of an induction coil. Only a single ambiguity catches our eye, where the iron core in a coil is said to have "the drawback that owing to the sluggishness with which the iron becomes magnetised, the secondary current is somewhat retarded behind the primary." With this exception the physics are far above the ordinary standard of electro-medical writers.

The first practical chapter (Chap. IV.) relates to the apparatus used in the application of statical electricity. That either sparks or a brush discharge can have any beneficial result other than secondary effects from nervous jar and irritation is very surprising; but there seems to be a considerable amount of evidence to support it. The most important method is the application of a positive brush discharge or "souffle" as it is called as a sedative in neuralgia, St. Vitus' dance, and some forms of headache.

The next chapter describes primary and secondary batteries and other apparatus. The types are well chosen, and useful practical hints are given on the use and care of batteries. We are surprised to find that the author is not at present prepared to recommend the use of current from the mains of supply companies, and suggests that "no doubt the best method of utilising the current so supplied is to charge accumulators." This use of a continuous supply ought to be of great value to medical men, not only for accumulators, or for cautery, laryngoscopes, &c., but also for curative purposes. Dr. Jones fears that by the use of resistances to reduce the pressure to the ordinary limits, much energy would be wasted, and he gives as an example the heating of a cautery with 25 amperes, when it would be necessary to use 3·9 ohms on a 100 volt circuit, only one-fortieth of the whole energy being used. This is a rather large current, unusually large, we believe, but at 7d. per supply unit it would cost less than 1s. 6d. for an hour, or 1d. for about $3\frac{1}{2}$ minutes. Alternating currents are no doubt more useful for such purposes, and a specially arranged adjustable transformer is described. In Chapter VI., where various pieces of apparatus are clearly illustrated and described, a protest is made against unnecessary names—rheophores for electrodes and wires, rheostats and rheochords for resistances, rheotropes for commutators, and rheotomes for contact breakers. The author does well in using the well-known names for these things, but he cannot shake off the expressions faradism and galvanism, for induction coil currents and battery currents. "To apply the coil," or "the battery" ought generally to suffice, but some adjective is required to describe the "current from a coil." The word "faradic" is accepted and recognised by medical men, who neither accept nor recognise the value of electrical treatment. A "coil" current is clumsy, and the ordinary "alternating" current will not do, for the current from ordinary alternators

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and transformers is an altogether different thing, and apparently of little value for medical purposes. A pair of words, "stabile" and "labile" have been adopted to denote the stationary and the stroking application of electrodes. We do not quarrel with these, as medical science is full of such terms, which have to a certain extent an international character.

The galvanometers for measuring the small currents used in medical work appear to be very unsatisfactory, even for continuous currents, while there is nothing to measure "faradic" currents with any real precision. It does not appear that medical men know whether the milliamperes of current from an induction coil play a more important part than the sudden kick of the pressure, but the "faradism" cannot be scientifically applied until it is quantitatively applied. They do try to measure their currents, however, and it is to be hoped that instrument makers will supply them with reliable instruments. The water voltameter which, it is suggested, may be used "to check the readings of a galvanometer or ammeter," is properly described as an exceedingly inaccurate instrument, "the corrections, too, are somewhat troublesome, though the method is so rough that they may be often omitted without much impairing the result." This speaks volumes for the value of the instruments which are thus to be checked. It is a pity that corrections are necessary, for, with charming simplicity, 100 milliamperes liberate about 1 c.c. of mixed gases in 10 minutes. The copper voltameter and the method of use is described, with notes on the necessary precautions.

With the physiological and pathological part of this book we are not so much concerned. Numerous authorities are quoted, the hypotheses are clearly stated, and the treatment is carefully described. Some observations are made on the flow of current in the body as a conductor, and in this connection it would appear that further attention should be paid to current density. Erb has suggested a number of standard sizes of electrodes for application to the skin. Their area in square centimetres and in inches is given, together with their diameters, but the names "small," "normal," "medium," "large," &c., are retained. The "dose" in milliamperes should be accompanied by the area of the electrode, from which the current density at the skin could at all events be found. The complicated electrical phenomena of nerve and muscle are described, together with the laws of electrotonus and muscular contraction. These have been tabulated, and are denoted by initials. K C C, for example, stands for "kathodal closing contraction," A O C for "anodal opening contraction." These symbols appear to be useful in diagnosis. The "reaction of degeneration" in paralysis is illustrated by some interesting typical curves of Erb. The use of the electric bath occupies a chapter, and the valuable application of electricity both for diagnosis and cure of infantile paralysis is discussed. In a chapter on electrolysis the destruction of nævi, and fibroids, and the treatment of strictures is described, and the volume closes with a chapter on cautery and surgical lamps. This work, which is fully illustrated, is essentially a practical handbook, and even if the chapters devoted to the curative applications of electricity are passed over with indifference by medical men, shrinking from a subject which has been tainted by quackery, they will find much valuable information on batteries, cauteries, and other surgical apparatus about which they need have no professional timidity.

The Hydro-Electric Methods in Medicine. By W. S. Hedley, M.D. (London: H. K. Lewis.)

This volume is largely a reprint from articles that have appeared in medical journals. These have little connection with each other, and the contents are not indexed. The last chapter or group, as the author calls it, deals merely with massage, and contains no more than a passing reference to electricity. The style is bright, but the general gossip is more interesting than the electro-medical part. "Roman ladies," says the author on the first page, "wore amber necklaces to cure their ailments. Was the amber necklet the prototype of some modern 'electrical appliance'? It was certainly superior from an æsthetic point of view, and could not possibly be inferior in point of electrical efficiency." The author feels the empiricism of the present state of knowledge, but seems to miss an important point in the following passage from the preface: "When our friends, the 'pure physicists,' smile (and not without reason, I admit) at the inexactness of our electrical methods, they do not always give due weight to the fact that we have to do with an animal organism, and not with a carbon filament or a copper wire." True; but even the physicist knows enough about physic to be aware of the importance of measuring a dose. Exactness in estimating the effect is desirable, but still more desirable is accuracy in measuring the stimulus.

Only one chapter deals with the subject indicated by the title, the electric bath. Some display of figures is made, but very little definite information is given about "the physics of the hydro-electric bath." The results of experiments are of some interest; in one case, the presence of a patient's body caused the flow of current to be deflected "round him and not through him," while it is recorded that in another case, "if one of the legs be held out of the water the current strength as registered by the galvanometer is reduced." The author shows that the apparent decrease of resistance and increase of current in a bath when the body is introduced, is due to the change of level of the water by displacement, and consequent increase of the sectional area. He concludes that only about 5 per cent. of the total current passes through the body. We fear that electricians and medical men will be unable to meet on common ground while the latter held such views as the following:—". . . For therapeutic purposes the alternating and continuous current may be regarded as almost two different agents. At the same time, it must never be lost sight of that the difference, strictly speaking, is one of degree—that it depends upon their being differently "cooked," so to speak, before being "served." By the time the continuous current has been run through the coil and chopped up by the interrupter, and, through inductive action, made more pungent and penetrating by the addition of electromotive force, it has become a very different thing, and 'a little of it goes a long way.'" We may be wronging the author by quoting this highly metaphorical passage, but it contains the suggestion of a real difficulty to which physiologists have paid too little attention, on which medical men have hardly troubled themselves, and on which the physicist can at present throw no light. The secondary current of an induction coil has been investigated by Blaserna and others, but no one to our knowledge has attempted to plot the curve of volts or current. The current being made more pungent by the addition of electromotive force is an expression which even a Chancery Q.C. would hardly use, but everyone can see what the author means, though no one has yet put it into scientific language.

It would be difficult but not impossible with existing methods to examine the curve of volts. The maximum can be judged by the sparking distance, the mean can be guessed from the mean current. The mean current is very difficult to measure, but we have no instruments by which the current curve could be recorded. Neither physiologists nor medical practitioners seem to know whether the volts, the current, or the coulombs is the quantity to be measured, or whether the stimulus is a complicated function of all. It is possible that sensation diminishes with increased frequency, the mean current remaining constant, but this has not yet been proved. Until these elementary matters are cleared up it is difficult to see how dosage with an induction coil can be intelligently measured.

The author seems to find great difficulties in using "the current from the main," and fears "an unexpected and undesirable increase of power," "the electro-motive force in the mains rising suddenly from some disturbing cause." The only possible way in which this could happen, if lightning be excepted, would be by the failure of his resistances, a most unlikely event if ordinary care is used, and far less to be feared than many surgical accidents. The author recommends a Cunynghame cut-out and an adjustable shunt besides adjustable resistances, but after all this complication he has nothing at all to say about "the therapeutic value of dynamo currents." A chapter on "the current that kills" is equally disappointing. Death from electric shock is compared to "a sudden fright or a blow on the epigastrium;" "we say that such cases have died from 'shock,' and we mean that the heart's action

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is suddenly arrested through nervous centres," a statement which might be expected from an intelligent coroner. Another "explanation" deals entirely with the uncommon case of a discharge through the brain. The author evidently takes an interest in the subject, and we hope that on some future occasion he will put forth a more useful and methodical work.

SEMAPHORE v. MORSE.

Signalling is a strong point with the British Navy, and it in more than one respect competes successfully with the "flag-wagging" of the Army. The favourite system is the old semaphore, which was the forerunner of the electric telegraph. The semaphore alphabet is fully ten times as easy as the Morse, if this proportion can be guessed at by the time required for learning one or the other; and any of our readers who want to while away a rainy afternoon at the seaside should repair to the nearest coastguard station, where they will find competent and willing instructors in the useful calisthenic exercise of semaphore signalling. Each letter is signalled by a single attitude of the arms, either with or without flags; hence the semaphore system is far more rapid than the Morse, but it suffers from the disadvantage that it is not easily adapted for use at night.

Signalling with a flash light, using the Morse code, is often preferred, since it can be seen so much further than the semaphore, even in daytime, and can also be seen in any direction, whereas the semaphore has to be slewed round so as to face the ships in turn which have to take in the signal. Taking about three miles as the limit of use of an ordinary deck semaphore in daytime, it is satisfactory to know that they can be illuminated so as to be used at night at about 1¾ miles; but they cannot compete for distant signalling with the flashing light which can be seen over 15 or 16 miles. Some difficulty was found in illuminating a semaphore so as to be seen at any distance at all at night; and the first idea was to build one like a star, with eight fixed arms, studded with incandescent lamps, any arm or pair of arms being switched on at will, the switch handles being worked similarly to the mechanical handles in daytime. The chief objection to this form of semaphore was that it was unsightly and unweildy, very liable to damage, and was only of use at night, and at the same time was considerably slower than the one used in daytime for two reasons—one being that the incandescent lamps took an appreciable time to attain and lose their full incandescence, and the other that the eye could not follow the arm. In daytime the eye follows the arms, and instinctively the letter is read as soon as the arms stop. With the star semaphore the whole semaphore was lost to view when the lamps went out and a complete letter was presented to the eye; this necessitated making the signal slower. The semaphore at present in use simply consists of the day semaphore with a square looking-glass reflector, with four 50 c.p. glow lamps fixed about two or three feet in front of the centre. This arrangement is satisfactory if the intensity of light on the arms is carefully adjusted. If the arms are painted white and all four lamps used, at a distance of about half a mile, the whole appears a blaze of light, and the motion of the arms cannot be distinguished. This is only natural, since near the centre of the arms the light is most intense, and at the same time the arms are closed together, and therefore a large apparent circle of light is reflected with the bare tips of the arms only distinguishable beyond it. It is inconvenient to have several reflectors and so distribute the light more evenly, but good results are obtained merely by painting the arms so as to graduate the reflection. For a radius of about one foot the arms and post should be dull black, then for another foot radius, red, and beyond that, white. By this means an approximately equal intensity of light is reflected from each part of the whole surface of the arm. The light required, as a rule, is not more than three 16 c.p. lamps. Methods have been tried to use the search light beams as semaphore arms, but at present have failed, chiefly owing to reflecting only a portion of the beam, and which small beam has not sufficient density to enable it to be seen at any distance on a clear night with a good arc. Even the whole beam of a 100 ampere light is a not very visible object; and if a semaphore of the kind is to succeed, the whole of the light must be used to form the two arms. Again, all letters involving the position of the arms below the horizontal are lost to sight at a short distance, unless the projector be placed in the top, or in some very high position.

Experiments have been made at Devonport on board the "Defiance" torpedo school ship. An ordinary search-light was fitted with a metal screen, so arranged as to either obscure the light altogether or allow it to be visible through narrow slits in the screen. The position of the slits represent the letters of the semaphore, and the beams passing through them are expanded by the reflectors. The experiments were interfered with by mist and rain, though we are not informed whether signalling by simple Morse flashes would have suffered to a greater extent. If the vertical system of lighthouse illumination, which was discussed some months ago, were really practicable, two radial beams might be easily contrived by means of a pair of mirrors, but, as in lighthouse work, such beams would only be visible under certain conditions of light haze. In addition to its speed the semaphore system presents the advantage that mistakes are far less likely to occur, since it is impossible to run two letters into one; a *t* and an *r*, for example, frequently appear as *c* in ordinary telegraphy.

As so many of our readers are familiar with the Morse code the semaphore code which we give below may be interesting to them. The first signal, Fig. 1, means "Alphabet," or "Attention," or "I want to speak," and at the same time shows the direction of the right and left hand of the signaller; since the semaphore, whether worked by the movement of the arms, or with a mechanical arrangement, is often liable to be read from behind as well as from in front. In the mechanical semaphore a small supplementary arm (Fig. 2) is generally fixed during a message to show the direction. "Flag-wagging" in the army is generally carried on by two men; one facing the distant signaller reads the messages, while the operator stands facing him, and with his back to the other station. There is no such right and left-handedness in heliograph or Morse flashing, and very little difficulty is experienced in semaphore work from this cause. The following diagrams represent the positions as seen, the two operators facing each other. The signal (Fig. 3) means that the following signals are to be read as numerals. It is not at all difficult to read a message from behind. It would seem that semaphore signalling might be carried out by three lamps, one to represent the centre round which the arms revolve, and the others the extremities of the arms. The former might be coloured, or rather less bright than the latter.

Alphabet

Fig. 1.

Fig. 2.

Numerals

Fig. 3.

This reminds us of the Kelway system of signalling which was shown at the Naval Exhibition last year and at the Crystal Palace. A number of glow lamps were arranged on a board, and by suitable wiring the depression of keys illuminated a sufficient number of these lamps to trace the outline of a letter. The only possible advantage of so cumbrous a device is, that it is legible by a perfectly uninitiated person. It was difficult indeed to see what use could be found for it; but an opportunity was afforded during the recent elections, when this system was used to signal the results to a crowd outside the National Liberal Club.

An attempt has been made, but at present with but little success, to introduce the semaphore system among the engineering staff of one of the principal railway companies. The "gaffer" could thus easily give orders to a man at a quarter of a mile or so.

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It is interesting to find that although the Morse code has become so common in all parts of the world, and is so applicable to needle instruments, sounders, printers, flashing, whistling, flag-wagging, tapping against a wall, winking, or kicking under a table, the semaphore should still hold its own, especially in the Navy. The alphabet is arranged in Fig. 4 in four sets of signals. In the first only one arm is used, in the second the right arm is at 45° below the horizontal, in the third it is horizontal, and in the fourth it is at 45° above the horizontal. The initial letters of these four series spell "a hot." The sequence of the signals greatly facilitates the memory. The letter M is rather difficult to remember, but L and N are easy, and M can be easily arrived at from either of these.

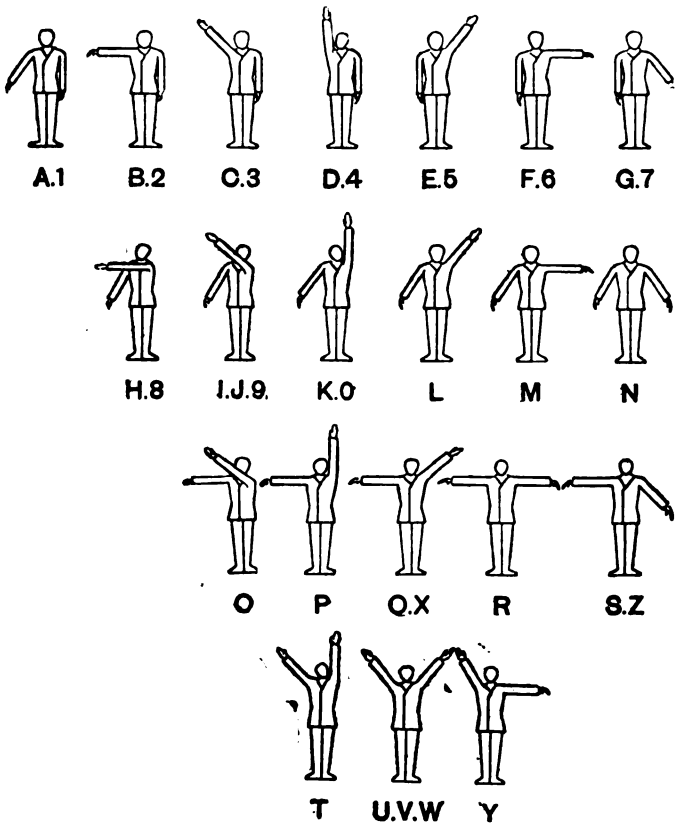


Fig. 4.—Semaphore Code.

The following additional signals have been lately introduced; they are given separately so that the symmetry of the main set may not be spoiled :—

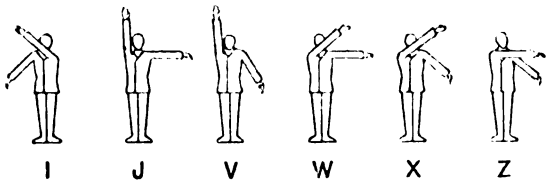
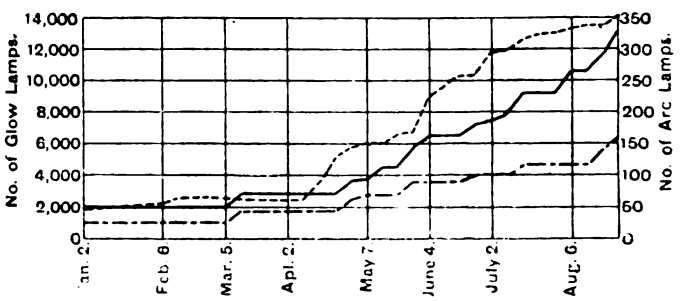


Fig. 5.—Additional Signals.

The much talked of search light on Mount Washington came into operation a few weeks ago. The light was designed by Mr. Lewis H. Rogers, of the Thomson-Houston Electric Company, who was anxious to see what search lights could do at such an altitude. With the co-operation of the various railway companies and hotels the plant was erected at a cost of $7,000, a tower 55ft. in height being built on the highest peak of the mountain. The projector stands on the highest part of the tower, and its movements are controlled by means of electric motors in a room below. The current is generated in the basement of the tower by a 100-ampere dynamo, driven by a 15 H.P. engine. The light at the lamp itself is stated to be 20,000 candles, but when projected into space from a Mangin mirror, 30in. in diameter, it is said to be increased to 100,000 candles. If, however, the beam is practically parallel as it should be for greatest penetration, the estimate of its candle power becomes meaningless, it would be infinite. Messages have been sent from Mount Washington to Portland by the Morse alphabet, and were easily read. The account given in the *Tribune* of these experiments is not very intelligible, for it puts the distance at 85 miles and says that as the source of light was far below the horizon, the beam was projected into the sky at an angle of 45 degrees. "In this way the lower strata of the clouds were avoided, and the pencil of rays was given a path that took it to a point probably 80 miles in the air above Portland, its length being calculated to be fully 110 miles." There are several discrepancies here. Mount Washington appears on the map to be less than 70 miles from Portland, and is 6,266ft. in height. The distance of the horizon from this altitude, without allowing for refraction, is about 110 miles; and a height of only 2,500ft. commands over 70 miles. However, it appears from further details that only the "sky flashing" was used, and the experiment is certainly of great interest.

THE CITY LIGHTING.

The popularity of graphic methods is evidently on the increase, for we now have a public company presenting the main facts of the year's operations to its shareholders, not by means of a wearisome array of tabular statistics, but in the shape of curves. The three diagrams which we publish below have been reproduced from some which are appended to the report of the proceedings at the second Annual General Meeting of the City of London Electric Lighting Company. These curves are of the simplest possible character, but we may hope, as time goes on, to



(Upper) ..... Progress Curve for Private Lighting (both Stations).
—— Progress Curve for Public Lighting (both Stations).
(Lower) ..... Progress Curve for Public Lighting (Bankside).

Fig. 1.

see others added somewhat more interesting and instructive, though perhaps more complicated; such, for instance, would be curves showing the number of units generated and metered each month, and the average number of pounds of coal consumed at different times of the year per unit sold. The idea is an admirable one, however, even if imperfectly carried out owing to the natural desire not to "give oneself away" by imparting too much information to the public at large and to possible trade rivals, and we trust that similar curves will in future be a feature of all reports emanating from the offices of electricity supply companies. Should the example set by the City of London Company be generally followed Mr. Crompton's demand for figures will be in a fair way of being met.

Turning to the curves of the City of London Electric Lighting Company we see from Fig. 1 that at the end of last month close on 350 arc lamps were connected up, or over 87 per cent. of the total number contracted for; at the present moment practically all the arc lamps under the City contracts are in operation. From the same diagram it will be seen that the private lighting has been rapidly growing, the total number of 8 c.p. lamps connected to the Company's mains at the end of August being 14,000. Figs. 2 and 3 show at a glance the financial status of the Bankside and Wool Quay stations respectively. As was only to be expected under the circumstances, the outgoings have considerably exceeded the incomings during the greater portion of the year. About the middle of July, however, the income curve of each station took a plunge, and crossed the expenditure curve, and since then the two curves

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appear to have been in a state of unstable equilibrium, in so far as their relative position is concerned. The dark days and King Fog will, however, doubtless soon dissipate the apparent hesitancy exhibited by the income curve in getting the upper hand of the curve of outgoings.

It is interesting to note that the Chairman, in his speech to the shareholders of the City of London Company, at the recent meeting, alluded to the special measures which had been or were about to be taken to obtain early information of the approach of fog. The Docks Committee it seems has promised to telegraph from the docks when fogs come up the river, and the placing of observers on elevated points around London in telephonic communication with the generating stations was also mooted. If fogs as a rule came down upon us like a tidal wave, these precautions would doubtless suffice; but if there

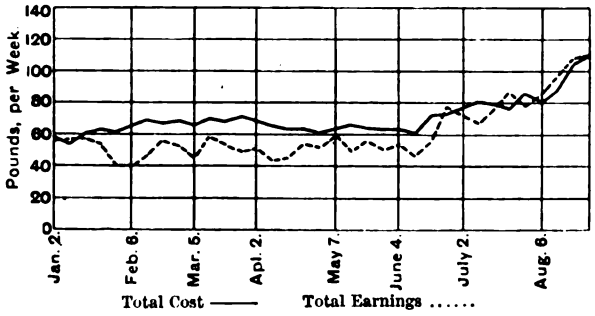


Fig. 2.—Bankside Station.

is anything more characteristic about a London fog than its colour and persistency, it is its frequent suddenness and sporadic distribution. Darkness rivalling that of midnight often supervenes within five minutes of comparative brightness, and as often as not passes away in thrice that time. These trying and

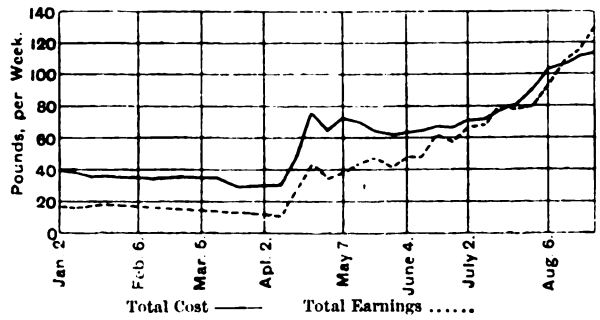


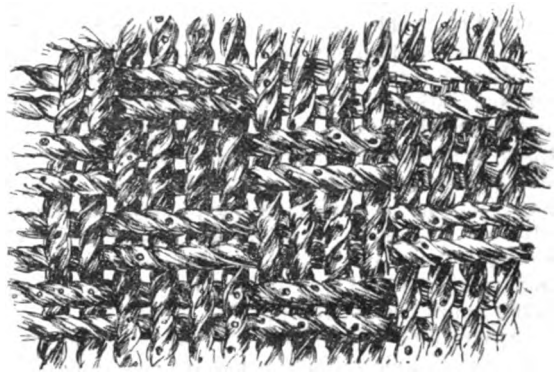
Fig 3.—Wool Quay Station.

peculiar conditions may be expected to give rise to ingenious expedients; but telegraphic fog warnings do not seem to us to promise anything like a complete solution of the problem.

It is interesting to note in this connection the different attitude assumed towards fogs by gas and electric light engineers. For a gas works manager a sudden fog has no terrors; all he dreads is persistent darkness, exhausting his reserves of gas. The central station engineer, on the other hand, has no storage to speak of, his only reserve is idle machinery, of which he has generally enough and to spare; hence fogs of long duration, provided no hitch occurs in the coal supply, are a positive boon to him, while a sudden darkness is his *bête noir*.

THE COLGATE SECONDARY BATTERY PLATE.

Although so very few new types of secondary battery plates ever come into commercial use, and in spite of the comparative disfavour of secondary batteries in America, a never ending stream of patents issues from the United States Patent Office, and hardly a week passes without some strange form of plate being illustrated and described in the columns of the technical press. The vast majority of the patentees aim at a light plate having a large active surface exposed to the electrolyte, regardless, perhaps, of the fact that if everything is to be sacrificed to these two considerations nothing can surpass a "lithanode" plate. As a sample of what is being done across the Atlantic we illustrate below the plate devised by Mr. Arthur Colgate of New York, which was described in the *Electrical World* of September 3. Its construction can be seen from the accompanying illustration. Long, narrow thin strips of lead are formed and then passed through a machine which perforates them, forms two longitudinal corrugations in them, and then twists them together with a rope of asbestos. These strands are next woven into a loose mat, such as is shown in the figure. Several of these mats are then put together under moderate pressure so as to form one plate, which is then inserted in a lead frame and is ready for use in the battery. The cell from which these details are taken is composed of four plates with a total weight of 8lbs. Each one of these plates is composed



of three mats 6in. by 8in. pressed together. The plates are $\frac{3}{32}$in. in thickness, and are separated by a space of about $\frac{5}{16}$in. The surface exposed amounts to 72 square inches of surface to each square inch of floor space occupied by the cell.

CONTINENTAL INCANDESCENT LAMPS.

A short time ago, writes Mr. C. J. Robertson, of the Elektrische Glühlampen Fabrik "Watt," I called attention to the recent English and American lamp tests as showing results far inferior to the older Vienna tests of continental lamps. Knowing from day to day what progress has been made in lamp manufacture on the continent since the latter tests were made, I was in a position to claim superiority for the continental lamps over the English and American ones; but I was not in a position to quote any independent figures. Since then, by the courtesy of Messrs. Ganz and Co., of Budapest, I have had the opportunity of examining and (through Mr. Déri) of publishing the following extract from a Report of the International Electric Company of Vienna to Messrs. Ganz and Co., of Budapest:—

"August 27th, 1892.

"The 15 glow lamps which the factory 'Watt' let us have for trial purposes were tested and gave the following values:—

Hours.	Average energy in watts.	Average c.p. in normal candles.	Life in hours.
0	49·75	16	1 lamp 55 hours.
50	49·70	16	1 „ 912 „
260	49·70	16	1 „ 1,080 „
670	49·60	15	1 „ 1,368 „
1,150	49·40	14	1 „ 1,660 „
1,730	49·00	12·5	1 „ 1,680 „
			1 „ 1,850 „
			The remaining 8 lamps still burning.

"(Signed) M. Déri,
"*Director.*"

For the sake of comparison I give a table below, wherein I have worked out the average watts per candle, and the mean

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percentage of original candle power, in order to compare them with the recent Ohio tests (See *The Electrician*, July 29) of the best American lamps :—

Hours.	Average watts per candle.		Mean percentage of original c.p.	
	"Watt" lamps.	G American lamps.	"Watt" lamps.	G American lamps
0	3·11	4·20	100 per cent.	100 per cent.
50	3·10	4·40	100 ,,	97·5 ,,
260	3·10	4·95	100 ,,	88 ,,
670	3·30	5·90	94 ,,	71 ,,
1,150	3·53	6·75	87·5 ,,	61 ,,
1,730	3·93	—	78 ,,	—

In the above table the lamps of 3·11 watts per candle should have changed their efficiency and candle-power at a far more rapid rate than those taking 4·2 watts per candle, if they had been equally well made. If the above lamps were considered to be "all out" when they had only dropped 22 per cent. from their original candle-power, then their average life would have been 1,280 hours for an average of 49·5 watts and for an average of 14·75 candles, whereas the American lamps would have been "all out" at 260 hours and taking an average of 72·6 watts and giving an average of 16·1 candles. On the basis of an average of 16 candles at the same watts per candle, this would, with the "Watt" lamps, be equal to an average life of 1,280 hours for an average of 53·7 watts.

The above results will answer the following points which several of the chief electrical papers have considered desirable of attainment on the part of lamp manufacturers :—(1) the production of a lamp which for a life of 1,000 hours should give an average of 16 candles for 56 watts ; (2) the production of a lamp which shall not vary much in illuminating power during its useful life, this object being even worth attaining at the expense of a slightly lower efficiency.

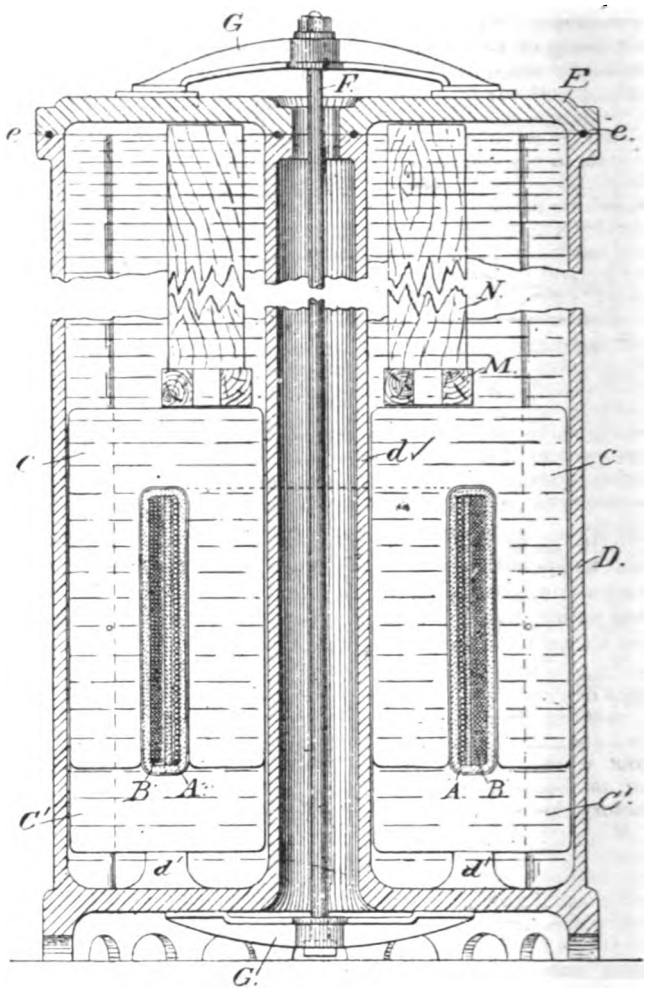
So much for a continental make of lamp of normal candle-power, taking at the start a normal number of watts per candle. On the other hand, Messrs. Siemens and Halske have been carrying out tests on some so-called "high efficiency" continental glow lamps (make not specified), requiring only 1½ to 2½ watts per candle with the results given in the accompanying table :—

Hours from start.	Watts required by lamps of		
	1½ watts.	2 watts.	2½ watts.
0	1·52	2·01	2·51
5	1·91	2·03	...
10	2·43	2·24	2·52
15	2·81	2·38	...
20	3·19	2·48	2·52
25	3·40	2·57	...
30	3·77	2·71	2·52
35	4·07	2·91	...
40	4·15	2·98	2·55
45	4·25	3·03	...
50	4·45	3·06	2·69
55	4·46	3·25	...
60	...	3·46	2·71
65	...	3·51	...
70	...	3·65	2·79
75	...	3·67	...
80	...	3·83	2·89
85	...	3·93	...
90	...	3·99	3·01
100	...	...	3·09
110	...	...	3·22
120	...	...	3·26
130	...	...	3·30
140	...	...	3·53
150	...	...	3·58

After ten hours the 1½ watt lamp is therefore more expensive to run than the 2 watt lamp, and the cost of the latter exceeds that of a 2½ watt lamp after 25 hours.

THE PYKE AND HARRIS OIL TRANSFORMER.

This transformer is constructed with all, or as much as possible, of the mechanical insulation of a permeable character. The transformer itself (see Figure) is placed in a corrugated container of earthenware D, serving at the same time as a cooling vessel, the height of which is about three times that of the transformer proper. The transformer consists of concentric coils of wire A and B, arranged so as to form a ring, which is arranged in sections, sepa-



rated from each other by porous insulating material which can be easily penetrated by the insulating liquid. The coils are held together by the iron of the transformer, C C and c' c', which is arranged in saddle-pieces placed vertically and radially, so that each set of plates enters one of the corrugations of the vessel. Each horseshoe plate encloses on each side a radial section of the coil. Each set of saddle-pieces is applied to the coil alternately from the top and from the bottom, and secured by corner bolts. The earthenware pot is provided with an axial tube, *d*, reaching to the top of the vessel. India-rubber packing rings, *e*, are placed in circular grooves between the vessel and the lid E. Washers, G G, connect the bolt F with the vessel and lid. An insulating ring, M, is placed in the top of the transformer.

Electro-Medical Apparatus.—In a recent communication to the Académie des Sciences, M. J. Morin described a new form of medical coil. After pointing out that in the ordinary form of induction coil where the primary is slid longitudinally into the secondary or where a closed conductor passes over the iron core, there is apt to be a sudden change of current strength possibly injurious to the patient, he shows how this may be overcome by constructing two flat coils side by side, one of which could be revolved into a plane at right angles to the other coil. It will readily be seen that in revolving through this angle the induced current gradually passes from its maximum to its minimum value. The author also points out how this arrangement may be utilised for converting a continuous current into a sinusoidal alternate current for electro therapeutic purposes.

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ON THE APPLICATIONS OF ELECTRICITY IN THE ROYAL DOCKYARDS AND NAVY.*

BY HENRY E. DEADMAN.

This is an age of electricity ; and the fact is well exemplified on board a model battle-ship of the Royal Navy. Some of the applications of electricity in the naval service do not come within the scope of ordinary mercantile practice ; and in the case of those which do, the naval experience is of a special kind, and may be of some value to those outside the service. A statement, therefore, of naval methods and practice up to date may not be without interest and instruction to the members of this Institution. At the present ime visitors to Portsmouth Dockyard will probably be surprised, not disappointed, at the somewhat primitive character of the workshops devoted to the electrical testing and construction. This branch of work was commenced in a very small way about seventeen years ago, and found a temporary home in a small shed which had been previously used for a different purpose. As the work from time to time has grown, this shed has been enlarged as far as available space would permit. Designs have been prepared for a more substantial and suitable building, in the hope that in time the Admiralty will be able to devote sufficient money to providing a proper habitation for this important branch of dockyard work. The larger proportion of the plant required for electric installations in the navy is not made in the dockyard. Formerly all dynamos and their engines were obtained entirely by contract ; but recently five sets of these have been designed and constructed in the dockyard. After patterns of the smaller fittings have been fixed, the supply of these also in bulk has generally been obtained by contract. There is, however, a great deal of work left to be done in the dockyard, in testing and installing these fittings in the ships, in carrying out repairs, and in devising and preparing patterns of new fittings to meet the constantly growing requirements of the navy. There is also some work, which for obvious reasons is confined to the royal workshops. The applications of electricity in the navy may be dealt with under the following heads :—(1) search lights ; (2) internal lighting of ships, including temporary installations in ships building and repairing ; (3) torpedo and gun circuits ; (4) electric communication ; (5) other applications.

Search Lights.

The introduction of the search light, without which no modern war ship or torpedo boat would be considered complete, dates from 1876 ; and the first vessel in the navy fitted with a search-light apparatus was the "Minotaur." Some experiments had been carried out in the previous year by Messrs. Wilde and Co., of Manchester, on board the gunboat "Comet ;" and these proved so far satisfactory that a complete plant was ordered and fitted on board the "Minotaur." The dynamo employed was one of the alternating-current type, with 32 magnets, and it was driven at about 400 revolutions by a belt from an auxiliary pumping engine. The projector was of a primitive type, and pedestals were fixed in three different places, from any one of which the same projector could be used. It was fitted with a parabolic reflector and with dioptric and diverging lenses. A diaphragm was also provided for enabling flashing signals to be made. The lamp employed was Wilde's, and was a vertical one. The carbon rods were square in section, and their holders were made to slide on two pillars, and were moved up and down by a central pillar with a screw thread cut in it. The lamp was hand regulated, and one lead was put to earth. The "Téméraire" in the same year was next fitted in a similar manner, with the exception that a Mangin projector was introduced, fitted with Wilde's lamp, lens, &c. In the next year, 1877, the "Dreadnought," "Neptune," and several other vessels were fitted with the same class of apparatus. In 1878 direct driving was first introduced. In this year Messrs. Wilde and Co. coupled their machines to engines made by Brotherhood and by Chadwick, of Manchester. The dynamo was also improved, so as to be able to maintain two arc search lights at one time. In the same year also the "Triumph" was fitted by Messrs. Siemens Brothers with a search-light installation. The dynamos were four in number, of horizontal type, arranged in two pairs, and each connected in parallel to one circuit. A switchboard was fitted, for enabling any two of these dynamos to be coupled up together on any circuit. It consisted of a wood base with two sets of bars at right angles to each other, one set on the top of the base and the other underneath. One set of bars was connected to the dynamos, and the other to the circuits. At their intersections these bars could be connected as required, by means of suitable plugs. The projector used was a Siemens holophote, which was heavy and clumsy, being made largely of cast iron. It was fitted with diverging and dioptric lenses ; of these the latter was composed of concentric glass rings of triangular section, held in a metal frame. It had also a flashing arrangement. The lamp used was one of the Siemens self-regulating type, and had a small mirror fixed to it. It was complicated, and frequently got out of order. The carbons were apt to stick together, and the lamp was sensitive to any slight variation in speed of dynamos. This lamp did not come into general use. Subsequently the Gramme dynamo was introduced for search lighting by Messrs. Sautter Lemonnier, of Paris ; and in 1881 the "Inflexible" was fitted with this dynamo. In this installation the Mangin projector was used, with a Mangin mirror instead of the dioptric lens. The lamp was hand regulated and inclined. The Gramme dynamo has since been superseded by others of later make ; but the Mangin mirror and the inclined hand lamp survived, and became the standard service fittings.

Naval Service Projector.—Out of these earlier attempts the modern naval service projector has gradually been evolved, which has now become familiar to most persons. It consists of a cylindrical lantern made of very thin steel, with a silvered glass parabolic mirror at the back end, in the focus of which an arc light is produced between two carbon sticks, held in what is known as an inclined hand lamp, the carbons standing at an angle of about 70deg. to the axis of the mirror. The feeding of the carbons is not automatic, but is accomplished by hand ; and the lantern is so suspended that it has motion on its pedestal through the whole circle in azimuth and through about 60deg. in altitude. During its motion the electrical connections are kept up by suitable rubbing contacts. A switch is fitted in the pedestal for switching the current on and off. The circuit wires, main and return, are brought from the main switchboard to the switch on the pedestal, thence to the rubbing contacts; and finally pass close together up one of the hollow arms of the lantern support, and through the trunnion bearing to two springs at the bottom of the lamp box. The lamp when put in makes contact with these springs, and completes the circuit through the carbons. Two sizes of these projectors are used in the naval service, a larger with a 24in. mirror for ships, and a smaller with a 20in. mirror for torpedo boats. The parabolic mirror in these projectors converges the rays into a powerful and penetrating cylindrical beam of light. At the front end of the lantern diverging lenses can be attached for spreading the beam over a larger surface when desired ; or a flashing screen can be affixed for signalling purposes. The two most important parts of these projectors for the production of a good and steady beam are, of course, the reflecting mirror and the carbons. For the supply of these articles the naval service was until recently dependent entirely upon French manufacturing firms. The Admiralty, fully alive to the dilemma in which this country might under certain circumstances be placed, have sought to induce English manufacturers to enter into competition with the French firms for the supply of these articles ; and everything of this kind which has been offered with the slightest promise of success has been fully and carefully tested at Portsmouth. The English manufacturers have no doubt had no easy task to accomplish ; for, disregarding cost, the French mirrors and carbons left nothing to be desired, and are still the standards to which all others are referred.

Mirrors.—As regards mirrors the qualities required are three :—first that they shall project a cylindrical, sharply defined, and homogeneous beam of light of great intensity and penetrative power ; second, that when in operation they shall not be liable to crack by contact with water, in the form either of rain or of sea-water spray, or by a blast of cold air ; third, that they shall resist the concussion caused by the discharge of heavy guns. These qualities should be combined at a moderate cost if possible, although efficiency is the primary consideration. Thus far mirrors have been submitted for trial by six different English makers, and by others specimens are being prepared for future trial. From among these at least one successful English specimen has been obtained, which compares in all points favourably with the French production ; and one half of the supply for the navy will this year be ordered from the firm producing this specimen.

Carbons.—With regard to English carbons the results were for a long time disheartening ; even after several attempts by the same firm, none of the specimens submitted for test approached in efficiency those of the French make. The three qualities required in good carbons are that they shall maintain a steady arc without flaming or excessive hissing ; that they shall be perfectly pure and homogeneous in structure, and shall preserve a well-formed crater on the positive carbon and a well-formed point on the negative ; and that the waste shall be steady and uniform, without cracking or crumbling. A certain amount of success has already crowned the persevering efforts of English manufacturers. Although the English carbons are not even yet fully equal to those previously obtained from France, it is hoped they will soon come sufficiently near that standard to make them acceptable for use in the navy.

Projector requirements.—The present service projector requires at least one man close to it to direct the beam of light in any desired direction, and also to feed and adjust the carbons as necessary. This is a disadvantage, because the position of a search light is evidently one affording a good mark for an enemy's fire, and is a bad position for observing the object illuminated ; and it would

* Paper read before the Institution of Mechanical Engineers, Portsmouth, July, 1892.

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be an advantage if the projector could be entirely manipulated from a protected position at some distance—for instance from the ordinary conning tower. For this purpose two requisites are necessary: first, a good automatic lamp; and second, an efficient motor for giving the necessary movements to the projector. It is to these two improvements that attention is now being given. A good practical automatic lamp is the first necessity; without this a man must be stationed at the projector to feed the carbons, and being there he can also direct the beam of light. Several automatic lamps have been tested, but none have as yet been adopted for general use. One lamp, in which the carbons are regulated by a small electric motor in a shunt circuit, is promising; but in its final form it has not yet been returned from the makers. The field, however, is still open for invention in this direction. Experiments have also been made with an electric motor attached to the service projector, by which the movements of the latter can be directed and controlled from a distance. The results are highly satisfac-factory, but, as already stated, the invention is not likely to be brought largely into use until it can be combined with a satisfactory automatic lamp. Recently a wheeled carriage has been introduced for using a ship's projector on shore.

Incandescent or Glow-Lamp Lighting.

Electricity is at the present day largely resorted to for the purpose of lighting internally the vessels of the navy; all the larger vessels, such as battle ships and first and second-class cruisers, are now so lighted. Moreover this mode of lighting is not restricted to the habitable portions of the ship, but is carried out to the complete exclusion of other modes, although the latter may be fitted as a reserve. Thus the electric lighting is extended to machinery spaces, coal bunkers, magazines, shell rooms, store rooms, gun quarters, &c., as well as to the illumination of compass cards, telegraph dials, bow and mast-head and signal lanterns, semaphores, &c. Clusters of glow lamps beneath an enamelled metal reflector are also employed for lighting the upper deck, when coaling or other operations are being carried on at night. In a large battle-ship like the "Royal Sovereign" there would be about 800 of these glow lamps, necessitating for this system alone about eight miles of electric leads, which are equivalent to something like 155 miles of copper wire of varying sizes, principally No. 20 legal standard wire-gauge or 0 036in. diameter.

Progress.—The first installation of internal lighting in the Navy was carried out on board the "Inflexible" in 1881 by the Anglo-American Brush Company. It was a combined system of arc and glow lamps. The dynamos used were of the Brush type, of which the first specimen brought to this country was purchased by the Admiralty, and is still in use in Portsmouth dockyard. Each machine was capable of maintaining 16 Brush arc lamps of 2,000 c.p. each. The lamps had double sets of carbons, each pair burning eight hours. These arc lamps were switched on and off by a switch opening and closing a shunt circuit of small resistance. With this plan it is evident a lamp could not be safely handled while the current was on, even if the light was switched off, because the lamp itself still formed a part of the circuit. A switch was accordingly devised in the dockyard, by means of which the lamp could be cut completely out of the circuit. The Swan glow-lamps were fitted in sets of 18 in series, each set being placed in parallel between the main circuits of the arc lamps. Each glow lamp was fitted with an automatic cut-out, bringing into the circuit a resistance equal to about that of the lamp, in case the latter failed. This system now no longer exists in the "Inflexible," an installation on modern methods having been substituted for it. The five Indian troopships were next fitted throughout with glow lamps by the Edison Company, who used the Edison-Hopkinson type of dynamo giving a current of 180 amperes at 110 volts. The "Polyphemus" was also entirely fitted by Messrs. Siemens, and the "Colossus" by the Brush Company, the dynamos in the latter being of the Victoria Brush type. The "Polyphemus" was the only ship in the navy fitted on the single wire-system. Afterwards the adoption of internal lighting became general; all new vessels except the smaller cruisers were fitted, as were also the previous vessels on the first opportunity of their coming in for repairs and refit. There are now in the navy about 300 vessels either fitted or being fitted with electric lighting, for search lights or internal lighting or both.

Difficulties.—The earlier installations, although quite satisfactory so-far as the illuminating effect was concerned, were certainly not satisfactory in regard to the endurance of the plant; in fact they were a constant source of trouble, both the dynamos and the leads requiring frequent repairs or renewals. These troubles arose partly from faulty construction, and partly from the conditions neces-sarily existing on board ships of war, such as the necessity for placing the dynamos well down in the ship, and under protection from shot; which relegated them either to the engine room with its high temperature and moist atmosphere, or to some other confined and ill-ventilated spot. Under these conditions the insulation soon suffered, and the machine quickly got out of action. The leads throughout the ship suffered too from access of salt water, which caused much trouble by destroying the insulation, and producing short circuiting, thereby frequently setting on fire the wood casing in which the leads were laid, or any other inflammable material in the neighbourhood.

Remedies.—Nearly all these difficulties have in the course of time been surmounted. While it is still necessary to place dynamos under protection for use in action, it has now become the practice to fit an additional dynamo, capable of running all the lights generally required at one time, and to place it with its motor in an open space between decks, or on the upper deck suitably sheltered. This is known as the peace or daylight dynamo. The introduction of lead-coated wires marked an epoch in ship-lighting; and these wires are entirely used in all the later installations, and are taking the place of the old leads as fast as the latter require renewal. These cables dispense entirely with the wood casings previously used, resulting in greater simplicity of fitting as well as increased efficiency. The wood casings are still used in America, even with the lead-coated cables; but in the writer's opinion, while adding largely to the cost of the installation, they are likely to detract from its efficiency, as they form such convenient receptacles for water to lodge in.

Dynamos.—The Admiralty have not adhered to any one particular kind of dynamo; for although those of the Siemens type predominate in the navy at present, nearly all the well-known makers are represented—such as Latimer Clark, Muirhead and Co., the Electric Construction Corporation, the Silvertown India-rubber Company, Goolden and Co, Crompton and Co., and Parsons and Co. The experience gained in the testing and use of these machines of different types was of immense benefit in enabling those points to be discovered in which dynamos are most likely to fail, and in suggesting the direction which improvements should take. The weak points in most of the machines supplied were imperfect insulation, owing to want of sufficient care in building: and the excessive internal heating of the armature. In some cases the section of copper used was too small, resulting in the heating of the dynamo and the rapid destruction of the insulation. By direction of the Admiralty a design was prepared by Mr. Lane, electrician of Portsmouth dockyard, for a machine to give an output of 400 amperes at 80 volts, which should embody the experience already gained, and should be free from the faults previously mentioned. Five machines have been built from this design, two of them for the "Rupert," a vessel now under reconstruction. No opportunity has yet occurred for testing them under the conditions of sea service; but two have been used for about a year under full load as temporary lighting plant for ships building, &c. At times, too, they have been worked for long periods above full load, from 420 to 430 amperes; and they have always given perfect satisfaction. They are driven at about 330 revolutions a minute by open vertical compound engines of 56 I.H.P., designed and constructed in the Chief Engineer's department of the dockyard. The total weight of the dynamo and engine with bedplate is about 5½ tons.

Other Fittings.—As regards the other fittings required to complete a successful installation—such as switches, fusible cut-outs, lamp-holders, shades, and their holders, &c.—patterns have been adopted or devised in accordance with accumulated experience, to meet the special requirements of the navy; these are simplicity, combined with strength to withstand the rough usage necessarily experienced on board a fighting ship. The guiding principle in the present installations is to make every part of the circuit inaccessible to water, by employing lead-coated cables, and by enclosing in metallic water-tight boxes all the principal switches and cut-outs, and by effecting in all cases in the interior of water-tight distributing boxes the subdivision of the mains, which themselves pass into the boxes and their subdivisions out of the boxes through water-tight stuffing glands.

Switchboard.—With several dynamos and a combined installation of incandescent and search lighting, a good switchboard is a necessity. The one generally used in the navy at present is susceptible of improvement; and a new switchboard has just been designed and made by Mr. Lane, the dockyard electrician, which promises to fulfil all the requirements.

Temporary Installations.—The employment of temporary installations of electric lighting in ships building and repairing has been a marked feature of recent practice in Portsmouth dockyard. Probably more has been done here in this respect than has been attempted in any other royal dockyard or private shipbuilding yard in the country, although these are now finding it to their advantage to follow the lead. So highly satisfactory have been the results of the experiments in this direction, that, with the exception only of the smallest ships, the electric light is now installed as a matter of course on board every new vessel at an early stage of its construction, and also in all vessels where repairs of any magnitude are to be carried out. The character of these temporary installations varies with the circumstances of each case. Where vessels are building in the docks adjacent to the electric shop, it is, of course, more convenient and economical to supply the current from

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a dynamo in the shop itself, the leads being carried to the ship on temporary wooden poles put up for the purpose. Vessels building on the slips, which are too far from the electric shop to convey the current to them in an economical manner, are served by a dynamo and motor placed at some convenient spot near the ship. After a vessel is launched, and generally for all vessels afloat, the most satisfactory method is to place a dynamo and engine with a steam boiler in the ship itself, generally in a temporary wooden house on the upper deck. By this means the light is maintained without interruption during the many movements of the vessel about the basins. The leads, lamps, &c., are fitted roughly. The cables are simply tied to clips fastened to the beams, &c. The switches are hung from the cables. The lamps, with their holders, are secured to wooden bases, and protected by wire guards without any glass globes.

Cost.—Although no exact comparison can be given between the cost of this mode of illumination and that of the old plan of lighting by candles, it is estimated that in a first-class cruiser like the "Royal Arthur" the total cost of the electric lighting during the whole period of building, including depreciation of plant, would be about £1,200. This would probably not much exceed, if at all, the cost of candles for the same period; but the vastly superior illumination obtained by the electric light—enabling work to be done better, more quickly, and under better supervision, to say nothing of the advantages in health and comfort to the workmen—would justify the continuance of this system, even though the actual cost should be much greater than that of lighting by candles. It is hardly an exaggeration to say that the excellent results as regards celerity and cheapness of construction, which have lately been attained in Portsmouth dockyard, could scarcely have been realised without the aid of the admirable illumination afforded by the system of incandescent lighting.

Testing of Dynamos.—Before acceptance from the makers all the dynamos purchased by the Admiralty are tested on receipt at a dockyard; and as no less than 150 have been tried at Portsmouth during the last two years—1890 and 1891—the experience gained has been considerable. At the north end of the electric shop a space is fitted with cast-iron holding-down plates, of sufficient area to take several sets of plant at one time; and also with an overhead traveller for lifting. Steam at 100lb. per square inch, or other pressure required, is supplied by three boilers of locomotive type in the adjoining boiler-house. Adjacent to the holding-down bed is a separate enclosed room, containing all the various electrical testing instruments; and into this room the leads from the dynamos under test are taken. For enabling a dynamo on any part of the holding-down bed to be rapidly connected up with the instrument room, two bare copper rods, extending overhead the whole length of the bed, are fixed to the roof trusses, and insulated by slate. From these are suspended two hanging leads, the lower ends of which can be connected to the terminals of any dynamo under trial. The overhead bars are coupled to leads, which pass through resistances sufficient to give the full load, and then into the instrument room. Nearly all the dynamos now purchased, except those for torpedo boats, are of a capacity of 400 amperes at 80 volts, the latter being the Admiralty standard voltage for all dynamos and electrical fittings; and they are all direct-current and compound-wound. The dynamos are coupled direct to open vertical compound engines, working generally with 100lb. steam pressure at a speed of about 330 revolutions per minute.

The dynamo and engine are required to stand first a continuous trial of six hours' duration with full load. Every half hour the steam pressure, current, and electromotive force are recorded, as are also the temperatures of the testing room, field-magnets, and armature. It is stipulated that one minute after the end of the trial the temperature of any accessible part of the machine must not exceed that of the testing-room by more than 30° Fahr.; and the maximum temperature of the armature at end of trial after stopping must not exceed that of the room by more than 70° Fahr. If these limits are exceeded by more than 10deg. the machine is liable to rejection. These tests for temperature are considered to be of great importance, for if unsatisfactory the dynamo is not likely to remain long efficient. The spare armature which is supplied with each machine is required to undergo a similar test for two hours. The Cardew voltmeter and the Siemens ammeter are the instruments actually used on board ships of the Navy. Very delicate instruments, such as electro dynamometers, are found not to be suitable for use under such circumstances. As additional tests the engines and dynamos are expected to stand without injury the sudden removal of the full load by the breaking of the circuit; and under such circumstances the maximum increase in revolutions or in voltage must not exceed 25 per cent. The dynamos are required also to be compounded so as to give a constant electromotive force of 80 volts when the current is varied from 400 to 10 amperes, the speed being fairly constant during the time; and they are fully tested to ascertain that these conditions are fulfilled.

Engines.—As regards the engines, great importance is attached to their economy in the consumption of steam. The makers are required to state the consumption of water per electrical horse-power per hour, which they will guarantee shall not be exceeded. A fine is incurred for every lb. of water per electrical horse-power per hour in excess of the maximum guaranteed; and if the excess amounts to more than 10lb. per hour the machine is liable to rejection on this account. The water used is carefully measured, and every endeavour is made to avoid losses by leakage of steam, &c. Importance is also rightly attached to the governing arrangements, and it is stipulated that the increase of speed when the load is gradually removed must not exceed 5 per cent.

Resistances.—Before the six hours' trial is started, and immediately after its conclusion, the resistances are observed of the dynamo complete, of the armature, and of the shunt and series-windings of the field-magnets; the resistances are thus obtained both when the circuits are cold and also when they are hot. For this purpose the leads from the terminals of the part whose resistance is required are taken into the testing room, and the resistances are obtained by a bridge made by the Silvertown Company, by a Thomson's marine galvanometer, and by an ordinary scale, for which the light is given by an incandescent lamp behind. The ordinary Daniell cells are used, and a key is introduced, so that one, two, three, or four cells may be switched in at once without altering the leads. The dynamo and engine are further tried when fitted on board ship, and when the whole installation is complete.

(To be continued.)

MAGNETIC VARIATIONS.*

BY WILLIAM ELLIS, F.R.A.S.

In this Paper the author refers to the ordinary variations of the magnetic elements as observed at Greenwich; the annual progressive change; the diurnal variation—large in summer, small in winter, and also larger when sun-spots are numerous and smaller when sun-spots are few; the irregular magnetic disturbances and magnetic storms, and the accompanying earth currents; phenomena which are generally similar at other places.

He then invites attention more particularly to magnetic disturbances. Those at Greenwich may, after a calm period, arise gradually or commence with great suddenness. When sudden, the movement is simultaneous in all elements. The first indication may be a sharp, premonitory, simultaneous movement, followed after a time by general disturbance, or the movement may at once usher in the disturbance. These initial movements are not always great in magnitude, sometimes, indeed, small, but they have a very definite character, and frequently occur nearly instantaneously, as is shown in the character of the photographic traces.

It has been long known that magnetic disturbances occur at the same time over wide areas of the earth's surface, but the accidental comparison in past years of the times of commencement of one or two disturbances at Greenwich with the times at other places has led the author to suppose that the coincidence in time is much closer than had been before supposed, and the definite, and on occasions isolated, character of the initial movement induced him to undertake the collection and comparison of the times of such movements for a number of days at observatories geographically widely separated.

The times of such movements cannot be caught by eye observation without continuous watching of the magnets, so that the photographic registers have to be relied upon, which is better, excepting that the scale of time is necessarily contracted; but, though in individual measures there might be variations, it was conceived that (supposing no systematic error to exist) the mean of a number of comparisons should give a good result. Seventeen days, occurring in the years 1882 to 1889, were selected for comparison, the observatories being those of Toronto, Greenwich, Pawlowsk, Mauritius, Bombay, Batavia, Zi-ka-wei, and Melbourne, and, for a less number of days, Cape Horn (as obtained from the Mission Scientifique du Cap Horn, 1882-83). It was desired to have times for Pola, but it was found that photographic registers during great part of the period did not exist. The variation in time at each place from the mean of times for all places is given for each day. The mean deviation at the different places varies from +2·4 minutes to −2·9 minutes, the agreement between four of the places—Greenwich, Pawlowsk, Mauritius, and Bombay—being very much closer, the mean values of deviation for Greenwich, Pawlowsk, and Bombay differing, indeed, by only 0·1 minute, equivalent to 6 seconds.

The question arises, Are the differences real, or due (considering the contracted time scale) to accidental error? If the magnetic impulse is really simultaneous over the whole earth, it is a striking

* Abstract of a Paper "On the Simultaneity of Magnetic Variations at Different Places on Occasions of Magnetic Disturbance, and on the relation between Magnetic and Earth Current Phenomena," recently read before the Royal Society.

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physical fact, and if not entirely so, the circumstance is no less interesting; but greater attention to accuracy of time scale, or a more extended scale, may be necessary before the point in question can be definitely settled.

A table is added, showing the character of the magnetic movement at the several observatories, from which it appears that at any one place the movements on different days were in most cases similar, though different at different places, indicating on these occasions the occurrence usually of one general type of disturbance.

Reference is made to the question of earth currents. A comparison for 31 days, between 1880 and 1891, of cases of sudden magnetic movement and earth current at Greenwich, shows the earth current to precede the magnetic movement by 0·14 minute, equivalent to 8 seconds. The question of the relation between magnetic movements and earth currents is discussed.

The desirability of being able temporarily to obtain, when occasion requires, a more extended time scale for all magnetical and meteorological phenomena is pointed out.

The general result is that in the definite magnetic movements preceding disturbance the magnets at any one place are simultaneously affected; also that in places widely different in geographical position the times are simultaneous, or nearly so, a small constant difference existing at some places which may be real or may be accidental, but the character of which it seems desirable to determine. It is shown also that at Greenwich definite magnetic movements are accompanied by earth current movements which are simultaneous, but that neither magnetic irregularities nor ordinary magnetic variations seem to admit of explanation on the supposition of being produced by the direct action of earth currents.

NUREMBERG CARBONS.

The French Vice-Consul at Nuremberg, M. Léon Duplessis, has recently made a lengthy report on the electric carbon industry of that town, from which we take the following extracts:—

"The manufacture of electric light carbons occupies six large factories, belonging respectively to C. Conradty, Ch. Shmelzer, Carl Braun, J. G. Meier, Emile Mahla, and Jules Fuchs. To these may perhaps be added a seventh, namely, that of Dr. Albert Lessing, though the latter does not produce carbons for electric lighting but only battery carbons.

"The raw material employed in this manufacture is 'retort graphite.' As far as the Vice-Consul was able to discover, this material only is used when homogeneous carbons are required; but when cored carbons are to be made a softer substance is added. Before they are ready for use homogeneous carbons pass through twelve, and cored carbons through sixteen different processes. The first operation is to break the graphite into small nuts. For this purpose a three-stamp mill is used. The stamps in falling crush the graphite placed over movable steel gratings that allow the broken material to pass between their bars. These bars are placed nearer to one another, or further apart, according to the size of the pieces required. Having passed this grating the pieces are collected by hand and passed through a sieve. The coarse particles are submitted to a vertical crushing, and the fine are passed on to a rolling mill. The vertical crushing is intended to reduce the pieces of graphite to about the size of semolina grains. The graphite thus treated is directed a second time into a sifting machine. Then follows more rolling. The sixth operation is to damp and mix the graphite obtained from the rolling mill, as well as the powder gathered in the sifting machines, with a binding substance. The mass delivered from this machine being too soft, it is necessary to render it plastic and capable of taking a shape, and with this object it is consigned to a sort of puddling machine which produces a species of paste. This paste is pressed through a machine fitted with dies. These produce coarse rods or other pencils, according to the diameter of the cylinders. The rods so prepared are introduced into steel hydraulic cylinders and submitted to a pressure of about 25 atmospheres. Some of these hydraulic presses—the construction of which the Nuremberg manufacturers have only attained by successive steps—can deliver 500 metres of carbon per hour or from 2,000 to 3,000 arc light carbons of average size. All these operations terminated, the carbons obtained are baked in a blast furnace where the temperature occasionally attains as much as 2,000deg. centigrade. When homogeneous carbons are withdrawn from the furnace they have only to be passed on to an automatic cutting machine. This machine is in direct communication with a ventilator which draws off the powdered carbon produced in cutting.

"The construction of machines employed in the manufacture of electric light carbons is also a Nuremberg specialité, and the house of Justus-Christian Braun has a monopoly of the business, and supplies machines in Europe and America. The cost of an outfit for a factory is put at 20·435 marks, irrespective of packing, transport, and Customs charges."

The following table is given as representing the average ruling prices of electric carbons at Nuremberg:—

Mm.	Per metre.		Mm.	Per metre.	
	Cored.	Homogeneous.		Cored.	Homogeneous.
	Fr.	Fr.		Fr.	Fr.
5	—	0·50	15	1·90	1·78
6	0·65	0·53	16	2·20	2·08
7	0·80	0·68	17	2·50	2·30
8	0·90	0·78	18	2·75	2·50
9	1·05	0·93	19	3·10	2·80
10	1·15	1·03	20	3·40	3·10
11	1·25	1·13	22	4·00	3·70
12	1·40	1·28	23	4·50	4·20
13	1·55	1·43	25	5·25	5·00
14	1·60	1·48	30	7·25	7·00

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 3, 1892.

The Niagara Falls Power Plant.—The Niagara Falls power plant is rapidly assuming definite shape. The tunnel on the American side which it was first intended to build through the solid rock without other walls than the natural stone, has, according to later plans, been lined with brick. The wall being 16 inches thick, the space between the brick work and rock has been filled with broken stone and cement, the original supporting timbers being left in place. This lining has reduced the capacity of the tunnel from 120,000 H.P. as originally estimated to about 100,000. The finished height is 21 feet and the width 19 feet with a cross sectional area of 365 square feet for its entire length of 7,600 feet. The grade is about 1 in 150 and there is a difference of level of 200 feet in the surface of the water in the canal and the tunnel discharge, about 140 feet of which will be available as a working head at the turbines. The manufacturer who locates at Niagara will have the opportunity of choosing between two methods of obtaining power; he may either put in his own wheel pit, penstock and wheels, and discharge the water into the tunnel as a tailrace, or he may equip his factory with electric motors and obtain his current from the immense power house which the Niagara Falls Power Company will build and operate. For the smaller manufacturer the latter method will probably prove to be the most economical arrangement, and it is probable that considerable demand will be made for current to be used in this way. To meet this demand the Company is putting in a station at which two turbines of 5,000 H.P. each will be installed at the outset. These turbines are built in this country from designs furnished by Faesch and Picard, of Geneva. The vertical shafts of these wheels will carry at their tops the armatures of two multipolar dynamos. The weight of the bearings is supported by the pressure of the water under the running head. This station is so designed that it can be extended to 50,000 H.P. ultimately. The wheel pit is now being excavated and is 140 feet in length and 18 feet in width.

The Chicago Exhibition.—The rapidity with which the constructors are pushing the World's Fair Buildings to completion may be judged from the fact that over 100,000 men are now employed within the grounds. Very little additional information is to be obtained regarding the department of electricity; it may be said, however, that the department is soon to announce the allotment of space to the different American exhibitors, and that it will be divided in accordance with the willingness and the ability of the intending exhibitors to make displays of the very best character. The incandescent lighting of the different buildings is being carried out in accordance with the original plans, except that they have been very much enlarged to meet the unexpected demands for

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interior illumination. The original designs contemplated the use of 100,000 incandescent lamps besides a large number of arc lamps; but present indications are that at least 250,000 and perhaps 300,000 will be called for. As now planned the manufacturers' building will have 28,000 incandescent lamps; the art gallery, 12,600; the annexes, 18,000; the administration building, 15,000; machinery hall, 7,600; and the basins, 6,100; the agricultural building, 5,000; Government building, 5,000; mining building, 4,800; transportation building, 3,200; woman's building, 3,200; choral building, 2,000; offices construction department, 1,800; fisheries' building, 1,000; Illinois building, 2,500; Pennsylvania building, 800; California building, 600; German building, 500; Japanese, 500; French, 500; other buildings, 25,000. Among the other buildings an average of about 200 each is assigned and for the midway plaisance, 15,000. This allotment does not include the electricity building, where 100,000 will be placed. The designs for the arc lamp posts are completed and are waiting for approval. Where single arc lamps are to be used the lamp will be suspended from the middle of a golden lyre, from which is raised a canopy of galvanised iron. Where groups of arc lamps are necessary a similar design will be used but having a triangular top in which three arc lamps will be suspended.

CORRESPONDENCE.

THE MAGNETIC CURVE TRACER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The remarks made in your Editorial Notes of September 9th suggest to me the desirability of adding a few words to what was said in Section A, regarding the use of the magnetic curve tracer to exhibit high-speed cycles of magnetisation. You refer to me as having "repudiated any mechanical inertia," but it should be understood that I was then speaking of certain phenomena which presented themselves when the cycle of magnetisation was gone through so slowly that no effects of mechanical inertia could have been sensible. At high-speeds the effects of inertia are, of course, felt, and appropriate means must be taken to avoid them. The case is similar to the familiar one of a steam-engine indicator. To adapt the indicator to high-speed working, we reduce to the utmost the mass of the moving parts and use a stiff spring. To adapt the magnetic curve tracer to high speeds we use a light mirror and tighten or shorten the stretched wires. In both cases we have to be content with a comparatively small diagram as a result of the stiffer spring or the tighter wire. In both cases ripples due to the free vibration of the working parts are liable to be superposed on the main cycle of movement; and to keep these within bounds it is essential that the period of free vibration should be many times less than the period of the main cycle.

In the instrument which I showed at Edinburgh, there was no difficulty in getting a satisfactory undisturbed diagram at any speed up to 20 cycles per second, or even more. But on the occasion of the lecture the weights that kept the wires tight were reduced for the sake of getting a big diagram projected on the screen to values which were just sufficient to allow a frequency of 10 or 12 cycles per second to be reached before the disturbing effects of inertia began to be felt. Unluckily, the revolving commutator, which was used to produce periodic reversals of the magnetising current, misbehaved itself towards the end of the lecture, the motor ran away, the speed became too high for the lightly loaded wires, and the curve was distorted—an effect mainly, if not wholly, due to mechanical inertia. Still more unluckily, what Lord Rosebery has just been calling the "sleepless editorial eye" transferred its impressions of this embarrassing moment to the editorial note-book in the sketch, which appeared in your British Association Notes of August 12th.

In reply to Prof. Perry's question, I named 20 cycles per second as a limit of speed within which the instrument exhibited had given a perfectly satisfactory B-H curve. To secure a good diagram at this speed the wires have to be somewhat tightly stretched, but not so tightly as to prevent the diagram from being fairly large. No doubt, with shorter and tighter wires and a lighter mirror, still higher speeds are practicable; but experiments in this direction have still to be made. For very high speeds I think it may be found best to use two mirrors, each having one component of motion, with successive reflection of the light from both.

In the chief use of the instrument, namely, the magnetic testing of samples of iron or steel, the cycle is gone through at so comparatively slow a rate that the mechanical inertia of the working parts is absolutely without influence. Using a revolving commutator of the type employed in my lecture, which gives gradual variation of the current from positive to negative and back, or from zero to any value, the observer will turn this slowly enough to follow with a pencil the movement of the spot of light over the curve. A much higher speed than is possible in this operation would still be so slow as to escape all disturbance from mechanical inertia.

When the samples are solid bars, the observer will find that he must go slowly, not because of mechanical inertia at all, but because of the sluggishness which the iron exhibits in taking up the full amount of magnetism proper to each value of the magnetising current. When the samples consist of thin sheet or of wire, this sluggishness is not found, and he may then go as fast as he is able to follow the movement of the spot.—Yours, &c., J. A. EWING.

Connel Ferry, Argyllshire,
September 12, 1892.

MAGNETIC VISCOSITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Messrs. Hopkinson's experiments are of great interest, and confirm in many respects the conclusions arrived at by Mr. Vignoles and myself more than a year ago, namely, that there is no magnetic viscosity making anything like 10 per cent. difference between the work done in carrying a piece of soft iron through a magnetic cycle in two or three seconds and in one hundredth of a second. It is true that the slow-cycle observations in Messrs. Hopkinson's Figs. 2 and 5 lie within the quick-cycle curve at those parts of the cycle taken just after the iron has passed through its nearly unstable condition; but in a Paper read to the Old Students' Association (*Electrician*, May 22, 1891, page 77) Mr. Vignoles drew attention to this effect, and stated that we had discovered the cause of the discrepancy, which we can assure Messrs. Hopkinson is not due "to something peculiar to experiments with the ballistic galvanometer," but is an effect of the very viscoscity of which they say "there is no sign." Had the slow cycle been obtained by the method described by Mr. Vignoles, Messrs. Hopkinson would have found it in almost absolute agreement with the quick-cycle curve. These points are fully dealt with in our forthcoming articles.

May I suggest to Dr. Hopkinson that he should add to the obligations under which he has already laid us, by publishing complete data of the experiments by which his results were arrived at, as without such information much valuable experimental work is rendered comparatively useless in future research.—Yours, &c. SYDNEY EVERSHED.

Woodfield Works, W., Sept., 13th, 1892.

[In Mr. Evershed's first article of the series on "The Magnetic Circuit of Transformers, Closed versus Open," *Electrician*, Vol. XXVI., p. 478, speaking of Prof. Ewing's model and the Weber-Maxwell theory of molecular magnets, he wrote, "It certainly seems well-nigh incredible that molecular magnets should be incapable of executing forced vibrations at what must, from a molecular point of view, be a very leisurely pace." In § 7, alluding to viscous hysteresis, he wrote, "As to a lag comparable with such short times as one-tenth to one-hundredth of a second, there is no evidence whatever of its existence and never will be until eddy currents are entirely eliminated from experimental results."—Ed. *E.*]

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THE USE OF BI-METALLIC CONDUCTORS ON ARMATURES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of September 9, 1892, you mention in your Notes "The Reignier and Parrot Dynamo." I wish to point out that MM. Reignier and Parrot are by no means the first in the field. My patents No. 126^{89} and 1068^{90}, and also that of Mr. R. E. B. Crompton, No. 5750^{90}, have entirely covered the ground as far as "bi-metallic" conductors on armatures are concerned in England. A single glance will show the superiority of the "Crompton" machine in the mechanical construction of the armature.

With regard to eddy currents in the conductors, the type used by Mr. Crompton and also by MM. Reignier and Parrot (an iron strip between two copper strips or simply a copper-plated iron strip) is singularly defective, being in fact the worst form of bi-metallic conductor. In all cases the iron should encase the copper and not *vice versa*, otherwise eddy currents will be set up along the copper on the sides of the conductor, as shown by the direction of the arrows in Fig. 1. For this reason I have entirely abandoned copper-plated iron conductors.

The best form of bi-metallic conductor is shown in Fig. 2 in section. This form reduces the magnetic resistance of the actual air gap by about 20 per cent., and is free from eddy currents. A third form consists of a copper wire wound over with iron wire or strip. This last is more suitable for small or for high tension machines.

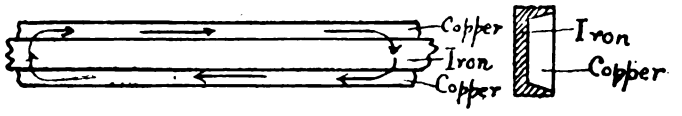

FIG. 1.

FIG. 2.

The possible output of any machine is limited by sparking only where no temperature limit is given, within reasonable limits. The sparking limit of a machine, the armature of which is wound with bi-metallic conductor, can be found from the following modification of Mr. Esson's formula which I have found to be correct in practice.

$$v = \frac{288\, I\,(l + \frac{d}{\mu})}{\phi}$$

where v is equal to the number of conductors on the armature multiplied by the current in ampères flowing in each, I is equal to the average induction per square centimetre, μ = the average permeability of the conductor, l = length of the actual air-gap expressed in centimetres, d = depth of the iron conductor, and ϕ = the angle embraced by each pole-piece.

From what I can gather, from the particulars given in last week's issue, and from "Industries" it appears that the "Reignier-Parrot" machine will reach the sparking limit at less than half load with ordinary clearance for the armature. About 1·1cm. clearance on each side would have to be allowed to prevent sparking. The number of ampère turns on the field-magnets to overcome the magnetic resistance of the gap space alone would be about 35,000. Any well designed four-pole machine would give the same output, if sufficient ventilation could be provided. The use of bi-metallic or iron conductor will not reduce the magnetic resistance of the gap-space (including conductors) without reducing the output of the machine. By the proper use of bi-metallic conductors, any machine can be worked up to its sparking limit without overheating. Since the possible output of any machine varies inversely as the angle embraced by the pole-pieces, it is evident that the possible output of any machine is doubled without increasing the total armature induction by using twice the number of poles of half the angular width. This fact is of no use in ordinary machines on account of the temperature limit, but with bi-metallic conductor wound armatures it can be made full use of. Magnetic leakage, spreading of the lines of force and cost of manufacture alone form the limit to the number of poles, and consequently of the output of the machine. Magnetic leakage and spreading of the lines of force over too great an angle can be compensated for by making the armature somewhat larger in diameter. By using a modified form of the "Mordey Alternator" magnet eight to twelve poles can be used on medium-sized machines without increased cost.

The following are a few particulars of one of my small four-pole motors, which runs without sparking or overheating:—Size, 15in. by 8½in. by 8½in.; weight, 71lbs.; speed, 1,800; potential difference at terminals, 35 volts; maximum current for continuous running without sparking, 35 ampères; electrical power absorbed, 1,225 watts; power on shaft, 1,000 watts or 1·34 H.P.; commercial efficiency, 82 per cent.; number of watts output per kilo. of dead weight, 31. The field magnets are of cast iron of doubtful quality. By substituting wrought iron cores the weight can be reduced to 55, which brings the number of watts per kilo. up to 40. The total number of ampère turns on the field magnets is 4,000.

—Yours, &c.,

G. B. LÜCKHOFF.

Croydon, September, 1892.

FIRE RISKS AND RULES IN AMERICA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A leading article under the above heading in your last issue refers to a communication which I have sent to an American journal on this subject. As your article is likely to create an erroneous impression of what I have stated, I feel called upon to endeavour to justify my statements, and also, with due deference and regret, to express my disagreement with most of the remarks and conclusions arrived at in your leader.

On the 23rd July last the *Electrical World* writes: "Fire underwriters are greatly disturbed by the increased fire losses said to be due to electricity. . . . . It is contemplated to increase the rates where electricity is used." And the journal solicited articles on this subject. I replied to this invitation by describing the state of affairs in England, asserting the fact, which I have on the best of authorities and which I firmly believe to be indisputable, that in England no such alarm is felt by the insurance companies, and that premiums are not raised where electricity is used, nor has a single fire occurred which could be traced to electricity as its cause. I endeavoured to prove that this very marked difference existing in the two countries is largely due to intelligent inspection; that rules alone are useless without the personal inspection by which we have benefited to so considerable an extent in England not only as contractors, but also as manufacturers of cables and fittings, and I concluded my remarks by advising the American insurance companies to establish an authority like Mr. Musgrave Heaphy.

To such advice you evidently take exception, and your own advice to the Americans may be construed from your remarks to be somewhat as follows:—"Do not imitate such rules and such inspection. The former are vague, and the latter is highly unpopular and has caused much annoyance. Allow matters to right themselves. We can discern many signs that you are bettering yourselves, thus you are taking the best possible course."

This is a direct contradiction to what I have advised. May I be permitted to ask what are the reasons which lead you to believe that matters in America seem to be taking the best possible course? Your article enumerates several reasons, chief among which are the following:—"The insurance companies are beginning to bestir themselves in the United States, and a meeting of electrical insurance experts has been held." This is no doubt a sign that something will be done, but it is also a sign that things are pretty bad in the States. "You understand that fire risks are decreasing. In 1889 there were 119 fires due to electrical causes, in 1890 there were only 75." This decrease is, according to our notions, scarcely satisfactory, and the less so in view of the announcement in July, 1892, that "fire underwriters are greatly disturbed by the increased fire losses." The third reason that you give to prove that matters seem to be taking the best

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possible course is to my mind still less convincing than the other. "You have been glancing through the advertisements in the *Electrical World*, and its Patent Record, and find that they teem with descriptions of improved contacts, switches, safety devices, wire claiming high insulating properties," &c.

As a general rule, I decline to accept the descriptions given in high-flown (especially American) advertisements as a proof of good quality. May I ask you whether you have seen or tested any of these advertised wires, switches, or insulators? I have, and in making the statements contained in my letter, I am not making them as merely derived from the perusal of newspapers, but am speaking from actual experience. I have found (of course you may take this as an individual opinion only) that the porcelain made in America is inferior in insulating properties to the china made in the English potteries—surface leakage owing to this cause, to the indiscriminate method of fixing screws, to covering them with substances like shellac, and to exposing them to the atmosphere without any covering, is of common occurrence in American electric light fittings. I also find an improper use of such hygroscopic substances as vulcanised fibre in cut-outs, holders, and switches. I have found no standards as to breaking distances, and divisions between poles, &c., and as regards the insulation of cables and wires, the very multiplicity of them proves that our transatlantic friends are very much at sea on this question, and that a little wholesome—even if "unpopular"—inspection might prove a boon to the contractor and manufacturer.

These questions and many more relating to articles used in wiring houses have received constant and careful attention in England with beneficial results, and let me ask the electrical trade, from the largest manufacturer to the smallest contractor, whom have we to thank for these results? and I feel confident that the majority will point to that inspector and to his interpretation of that code of rules which you have characterised as "highly unpopular, and causing so much annoyance," and which you wish to condemn on account of their "vagueness and need for separate interpretation," as if, during the past stage of electrical manufacturing, and even at the present moment, any more definite rules could possibly be devised without being subject to almost weekly alteration. What was considered the best yesterday has to be condemned to-day. Inventions and improvements are being made almost daily, and this "vagueness" of rules will doubtless disappear as soon as electrical manufacturing has arrived anywhere near perfection, but this "separate interpretation," this close inspection have been the very best thing possible for us as manufacturers and contractors. That the inspection has caused some annoyance and been unpopular cannot be denied, but its unpopularity is becoming less and less marked as the purport and beneficial influence of such inspection is more and more understood and appreciated.

American electrical engineers might do worse than subject themselves to such "annoyance," or to work under such "unpopular" interpretation of rules.—Yours, &c.,

London, Sept. 12, 1892. G. Binswanger.

SUBMARINE TELEGRAPH RELAYS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to your Editorial comment in *The Electrician* of August 26th, on the performance of M. Willot's relay between Paris and Algiers, four words per minute, it may interest you to know that nearly four years ago (September 16, 1888) twenty words per minute were received by sounder at St. Pierre (Miquelon) from Duxbury, Mass., over the Anglo-American Cable; distance, 878 miles; resistance, 8,300 ohms; capacity, 256 m.f. In this test a Brown and Allen relay was used as receiver, and a system of transmission of my own invention was used at Duxbury.

I do not know the character of the Paris-Algiers circuit, but from the map the distance appears to be about the same as from Duxbury to St. Pierre. I expect to obtain much better results than the foregoing in a trial soon to be made with my complete system of cable telegraphy.—Yours, &c.,

South Orange, N.J., Sept. 6th. Patrick B. Delany.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Tenders Invited.—Tenders are invited by the Corporation of Southampton for the electric lighting of the Corporation waterworks at Otterbourne, near Shawford. Specification and form of tender may be had and all further particulars obtained upon application to Mr. J. G. W. Aldridge, electrical engineer, at 9, Victoria-street, Westminster, and at 23, High-street, Southampton, after the 15th inst. Tenders must be in by 2 o'clock on the 27th inst. Further particulars are given in our advertisement columns.

Plant for Sale.—Our advertisement columns contain a notification of the sale by private treaty of the lease of the premises lately occupied by Mr. J. Collins at Hove, together with the modern stock of electrical plant. Full particulars may be obtained of Messrs. Ward and Wilding, chartered accountants, Bloomsbury Mansions, Hart-street, London, and 8, North-street, Brighton; or of Messrs. Bullock and Sadler, 33, Queen's-road, Brighton.

Works and Plant for Sale.—The electrical and engineering works at Carntyne, Glasgow, recently occupied by Mr. Rankin Kennedy, are to be sold by public auction at the Faculty Hall, Glasgow, on Wednesday, October 5th, at 2 p.m. Inventories may be seen and all further information obtained on application to Messrs. Dunlop and Murray, C.A., 82, West Regent-street, Glasgow, or to Messrs. Carruthers and Gemmill, writers, 62, Bath-street, Glasgow. Further particulars are given in our advertisement columns.

Berwick.—At the last meeting of the Berwick Urban Sanitary Authority, the Mayor, in answer to inquiries, stated that the matter of lighting the town by electricity was still before the committee appointed to consider the question.

Blackpool.—We are asked to state that as the Corporation have taken over the plant of the Blackpool Electric Tramway Company (Limited), all communications for this department should in future be addressed to the General Manager (Mr. John Hesketh), who is also the borough electrical engineer.

Essex.—At the last meeting of the Shire Hall Committee the subject of lighting the Shire Hall and Clerk of the Peace's office by electricity was under consideration, but owing to the fact that a consulting electrical engineer asked for the exorbitant fee of 20 guineas for going carefully into the question and advising the committee, it was ultimately decided to reject the special committee's recommendation to adopt the light.

Hammersmith.—The Hammersmith Vestry have resolved to apply for a Provisional Order, empowering the Vestry to supply the district with the electric light.

Hayle.—Mr. F. M. Newton, of Taunton, has completed an electric light installation at Copperhouse, a large establishment owned by Messrs. J. and F. Pool, metal perforators and ironmongers, Hayle.

Oldham.—The Oldham Board of Guardians have appointed a committee for the purpose of investigating the best means of lighting the workhouse by electricity.

Western Union Telegraph Company.—This Company announce that they have opened a new office at 40, Mark-lana, E.C., for the reception and delivery of messages for and from all parts of North, Central, and South America, Canada, Bermuda, Bahamas, West Indies, &c.

Fire Protection.—We have received from Messrs. Merryweather and Sons (Limited), of Greenwich-road, a pamphlet giving practical hints on fire protection of towns and buildings. Accompanying the pamphlet are illustrations showing designs of the various engines and other apparatus and specialities manufactured by the firm for fire extinction. The pamphlet is written by Mr. J. Compton Merryweather, M.I.M.E.

Copper.—Messrs. E. le Bas and Co. inform us that the Mint, Birmingham, Limited (Ralph Heaton and Sons), for whom they are the sole London agents, have just completed their hot-rolling mills department for brass and copper sheets and rods. They also make a speciality of high-conductivity copper wire, sheets, rods, and all kinds of tubes. They have also a special department for all kinds of stampings and spun work in copper and brass.

New Branch. — Messrs. Woodhouse and Rawson, United (Limited), have opened a new branch office at 13, Paragon-arcade, Hull.

Removal Notice.—The registered offices of the General Electric Power and Traction Company (Limited), have been removed from New Broad-street House, New Broad-street, to Worcester House, Walbrook, London, E.C.

Appointment.—The Dundee Gas Commissioners have appointed Mr. James Small Borough Electric Lighting Inspector.

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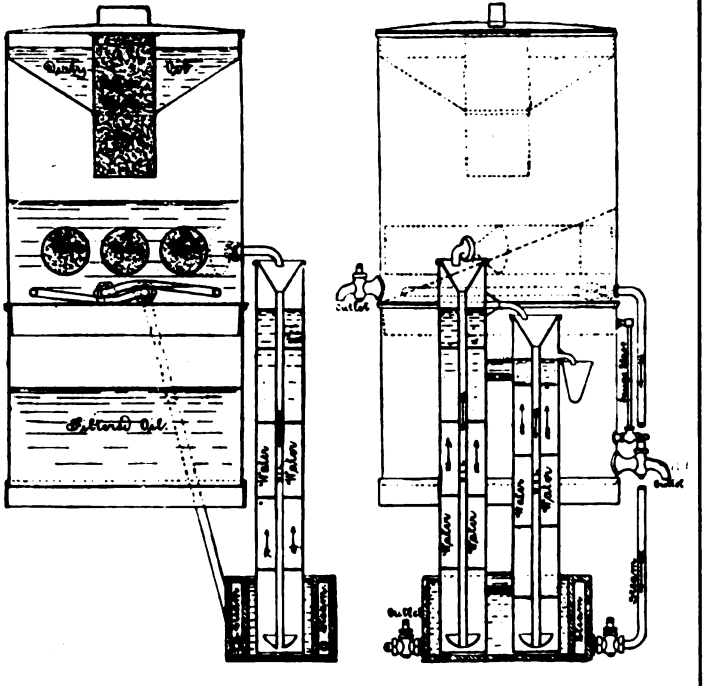
Electric Launches.—Messrs. Woodhouse and Rawson, United (Limited), inform us that they have on view at their show-rooms at Cannon-street, E.C., a working model of the electric launch Glowworm recently designed and built by them for Mr. Andrew Pears.

Wiring in the City.—We are informed that the contracts for the wiring and fitting of Leadenhall House, New Zealand Chambers, and Billiter-avenue Buildings, comprising over 1,500 16 c.p. lights have been signed this week by Messrs. H. Binko and Co., of 34, Leadenhall-street.

W. T. Henley's Telegraph Works Company (Limited).—In reference to the paragraph which appeared in our last issue concerning the winding-up of Henley's Telegraph and Electric Construction Company (Limited), we are asked to state that this winding-up has no reference whatever to W. T. Henley's Telegraph Works Company (Limited).

Turner Patent Oil Filter.—We have received from the Turner Patent Oil Filter Company, of Preston, Lancashire, particulars of their patent filter, for which they claim many advantages over other filters in the market; included in these claims is one that the "Turner" filter is alone capable of effectually cleaning spent and impure oils, and removing all traces of water therefrom. Our illustration gives a view of the No. 1 size filter, for which printed



working instructions are issued by the Company, and which are simple and easily acquired. By the use of these filters water, grit, dirt, and all metal particles are removed, and the spent oils can be used over and over again. The filters are made in several sizes, to filter from four to 100 gallons per week. They have been adopted by the Post Office Telegraphs Department, and are in use at a number of electrical engineering works in this country and abroad.

Messrs. Dorman and Smith.—We have received the newly-issued illustrated price list of this firm giving full particulars of their manufactures, including holders, switches, regulators, switch-boards, cut-outs, wall sockets, ceiling roses, pendants, brackets of all kinds, and a variety of ships' and general fittings for the electric light. The list contains nearly 100 illustrations of goods actually manufactured by the firm. It is satisfactory to note that Messrs. Dorman and Smith's new large works at Salford are now in full work.

Edison and Swan United Electric Light Company.—We hear on good authority that the reports which are being circulated as to the strike at the works of this Company are much exaggerated. No interference with the general business of the firm is anticipated.

Poole and White (Limited).—On the application of Mr. L. Hervé, Mr. Justice Bruce (the vacation judge) made an order for the compulsory winding-up of this Company on Wednesday last.

Electrical Engineering Corporation, Limited (in liquidation).—We learn from Mr. F. W. Pixley, the receiver and manager of the above Corporation, that as the realisations of the assets will not pay 20s. in the pound to the debenture-holders the unsecured creditors will receive nothing.

Siam Electric Light Company.—We understand that the affairs of this Company have been satisfactorily settled, the Treasury having advanced £20,000 for the payment of creditors. Upon certain conditions the Brush Electrical Engineering Company undertake to put the machinery in order, after which the concern will either be sold by auction or the Government will take it over by private arrangement.

Electrical Cookery.—Not to be behindhand in matters electrical, the chief citizens of Ottawa were recently invited to a banquet in which the cooking was entirely done by electricity. Amongst the company was the Mayor of Ottawa. The electrical caterer was Mr. T. Ahearn, of Messrs. Ahearn and Soper, of Ottawa. The entire *menu*, including the bread, was cooked and prepared electrically, and the banquet was a phenomenal success.

Sanitas.—Owing to the cholera scare the Sanitas Company have had a tremendous demand for their manufactures, which has necessitated their works being kept going night and day for some time past. Many of these orders are from large engineering establishments throughout the country who have found the Sanitas specialities most valuable disinfectants.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by Mr. J. C. Chapman, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

August 15, 1892.

14,700. J. D. Morrison. London. A method of making and using binomic baths to mechanico-chemically and hydro-electrically exalt the health of the people.

14,719. T. Floyd. London. Improvements in and relating to electrical storage batteries.

14,720. A. J. Jarman. London. Improvements in and relating to electrical storage batteries.

14,738. C. Coerper. London. Improvements relating to electric arc lamps.

August 16, 1892.

14,769. W. P. Thompson. Liverpool. Improvements in brushes for dynamos. (H. H. Cherry, S. D. Younglove, L. House, and W. C. Raymond, United States.)

14,799. A. H. Vesey. London. Improved electrical switch.

14,805. H. R. Low. Twickenham. Improvements in electric arc lamps.

14,806. H. R. Low. Twickenham. Improvements in motors for alternating currents.

14,813. F. P. Usher. London. Improvements in electric battery plates.

14,814. E. P. Usher. London. Improvements in storage batteries.

14,815. E. P. Usher. London. Improvements in storage batteries.

14,816. E. P. Usher. London. Improvements in electric battery plates.

14,819. H. Wyatt. London. Improvements in and relating to electric arc lamps.

14,822. H. H. Lake. London. Improvements in incandescent electric lamps. (Eugene McOuat, United States.)

August 17, 1892.

14,859. H. L. T. Lyon. London. Improvements in telephonic connections.

14,886. A. Wright. London. Improvements in cut-out switches and cases for containing and protecting the same.

August 18, 1892.

14,928. F. H. Medhurst. London. A new or improved non-sparking switch.

14,947. A. J. Jarman. London. Improvements in the plates or electrodes of electric storage batteries.

August 19, 1892.

14,974. W. T. Goolden and S. Evershed. London. Improvements in electric measuring instruments.

15,002. J. Hines. Liverpool. Improvements in telephony or means for transmitting telephonic signals through long distances.

August 20, 1892.

15,035. J. H. Rider. Halifax. Improvements in automatic switches.

15,038. A. E. Vidal and G. Herveen. London. Improvements in electrical winding mechanism for clock movements.

15,057. J. Brockie. London. Improvements in electric arc lamps.

15,059. H. C. Gover. London. Improvements in portable electric incandescent lamps, and in battery cells and fittings therefor; also partly applicable to electric batteries generally.

15,066. C. E. Webber and G. H. Nisbett. London. Improvements in electrical cut-outs for high-tension currents.

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August 22, 1892.

15,113. J. P. Roubertie, V. Laperye, and U. Grenier. London. Manufacture of caustic soda and potash and hydrochloric acid by electrolytic treatment of chloride of sodium and chloride of potassium, and apparatus for this purpose.

15,120. H. W. Headland. London. Improvements in or applicable to electrical accumulators or secondary or storage batteries.

August 23, 1892.

15,167. B. J. B. Mills. London. Electrically illuminated signs or devices, partly applicable to other purposes. (A. D. Page and E. J. McAllister, United States.)

15,179. J. R. Bailey, L. C. Lincoln, and The Woonsocket Edge Tool Company. London. Improvements in arm rests for telephone operators.

15,187. A. E. Le Rossignol. London. Improvements in working and regulating glow lamps and in apparatus therefor.

15,188. E. F. H. H. Lauckert. London. Improvements in electric arc lamps.

15,194. E. L. Mayer and A. C. Jameson. London. A new or improved telephone transmitter.

15,197. H. M. E. Andreoli. London. Improvements in electrolytic apparatus.

August 24, 1892.

15,238. A. R. Bennett. London. Improvements relating to telephonic switching apparatus.

15,240. Hayward Tyler and Co., and C. P. Hammond. London. Improvements in joining or junction boxes for electric cables or wires.

August 25, 1892.

15,296. H. C. Bull and J. Ramage. Liverpool. Improvements in and appertaining to electrical accumulators.

15,298. F. Bryan. London. Improvements in holders for incandescent electric lamps.

15,315. R. W. H. Newington and E. Priddle. London. Improvements in electrical batteries and their application for curative and remedial purposes.

15,318. H. H. Leigh. London. Improvements in electrical transformers. (G. M. Apollonj, Italy.)

15,319. D. Federman. London. Improvements in and relating to electric batteries.

August 26, 1892.

15,329. E. Horton. Birmingham. Improvements in gas, electric light, and lamp fittings.

15,356. H. C. Bull. Liverpool. An improved electro-chemical process for treating iron pyrites thereby recovering everything valuable contained therein and avoiding all noxious fumes.

15,372. W. Boggett. London. Improvements in the method and means of obtaining electricity.

15,376. F. O. Clapcott. London. An improved system of automatic telegraphy.

15,377. R. L. Hattersley. London. Improvements in switches for electric lighting.

August 27, 1892.

15,405. H. Oppenheimer. London. Improvements in and connected with telephone switches.

15,426. J. W. Savage. London. Manufacture of an elastic compound for electrical insulation and other purposes.

15,437. W. E. Gray and W. A. Price. London. An improved method of making electrical contacts between parts of electrical apparatus.

15,441. A. J. Howes. London. Improvements in arc electric lamps.

August 29, 1892.

15,477. A. F. W. Kreinsen. Manchester. Improvements in the means for, and method, of melting metals and other materials by electricity.

15,492. H. H Lake. London. Improvements relating to the lubrication of parts of machinery with the aid of electricity. (J. F. A. Höper and A. Jacobsen, Germany.)

15,501. J. Domecq-Cazoux. London. Improvements in means for lighting oil lamps by electricity.

August 30, 1892.

15,552. W. J. Eastman. London. Improvements in and relating to electric cigar lighting lamps.

15,591. J. C. Wüst. London. Improvements in electric arc lamps.

August 31, 1892.

15,649. J. Stoerk. London. Apparatus for continuous decomposition of alkaline chlorides by electrolytic fusion.

16,650. G. G. di Giovanni. London. Electric apparatus for illuminating the sights of firearms at night.

September 1, 1892.

15,665. J. Dick and W. Scott. A method of eliminating the cross magnetism in the armatures of continuous current dynamo-electric generators and motors.

15,671. D. Balmford. Bradford. Medicated electricity or special use and application of electricity for medical purposes.

15,689. C. R. J. Willot. London. Improvements in relays for electric telegraphs.

15,690. B. and A. Kochs. London. Improvements in overhead trolley for electric railways.

15,691. C. Drill. London. Improvements in electric air ships.

September 2, 1892.

15,746. H. P. Fils. London. Improved globe for reflecting arc lights.

15,767. W. Moscrop. London. Improvements in gas outlet valves or plugs for electric battery cells or other like vessels.

15,790. H. C. Gover. London. An electric lantern.

15,793. C. G. P. de Laval. London. Method of smelting or overheating iron or other metals by means of electricity. (Date applied for under Patents Act, 1883, section 103, March 8, 1892, being date of application in Sweden.)

15,795. S. F. Walker. London. An improved system of electrical distribution.

15,799. E. Nunan and J. W. Nelson. London. An improvement in galvanic batteries.

September 3, 1892.

15,813. A. M. Thompson. Crewe. Improvements in the formation of junctions for electric mains.

COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

The following report of the Directors for the half-year ended 30th June last will be presented at the general meeting of shareholders, to be held on Tuesday next, the 20th inst., at Winchester House, Old Broad-street, E.C., at 2 p.m.:—

The accounts for the half-year ended 30th June, 1892, show, after providing for debenture interest, a balance to the credit of profit and loss of £5,438. 2s. 7d. The traffic receipts show a decrease of £45. 8s., as compared with those of the corresponding period of 1891. They may, however, be considered satisfactory, as in the half-year of 1891, with which they are compared, the present reduced tariff had not come into force. The working expenses are £170. 7s. 7d. in excess of those for the corresponding period of last year.

The Company's cables, and the land-lines in connection with them, have continued in good working order throughout the half-year.

After putting the usual sum of £2,500 to the reserve fund, the balance of profit and loss amounts to £2,938. 2s. 7d. Out of this amount the Directors recommend the payment of the dividend at the rate of 10 % per annum on the preference shares, and a dividend at the rate of 4 % per annum (free of income-tax) on the ordinary shares. There will then remain a balance of £441. 3s. 0d., which will be transferred to the reserve fund in part repayment of the sum of £2,376. 12s. 4d., taken from that fund towards the repairs of the Falmouth-Bilbao Cable in November, 1891. The reserve fund will then amount to £29,827. 2s. 10d. The dividend warrants will be issued on the 1st of October, 1892.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades' Directory and Handbook, 1892, pages 308-322, *&c., &c.*

ARMSTRONG'S ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This Company was dissolved under Clause 7 (4) of the Companies Act, 1880 (43 Vict. ch. 19), by notice in the *London Gazette*, dated August 16, 1892. The Company was registered on November 2nd, 1887, with a capital of £20,000 in £1 shares. Repeated notices were sent to the Company signifying that noncompliance with the regulations would result in the striking off of the Company from the register ; and as a result, the usual proceedings have been taken.

CALIFORNIA GAS, WATER, AND ELECTRIC LIGHT COMPANY SYNDICATE (LIMITED).—The statutory return of this Company, made up to April 15, 1892, was filed on August 30, 1892. The nominal capital is £2,000, in £1 shares. Of these, 1,475 have been taken up, the full amount called, and all calls (£1,475) paid. Registered office, 20, Bucklersbury, E.C.

CITY NOTES, &c.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED). — The Directors of this Company have resolved to recommend, subject to audit, a dividend at the rate of 6 per cent. per annum on the preference and ordinary shares of the Company for the six months ended 30th June, 1892, making, with the interim dividend paid last February, 6 per cent. for the year. The transfer books of the Company will be closed from the 19th to 28th September, both inclusive. The meeting of the shareholders will take place on Tuesday, the 27th September, at Winchester House, E.C.

CALLS DUE.—*24th Sept.*: National Telephone Company (Limited), £1 10s. per share on 90,950 £5 per cent. non-cumulative 3rd preference shares of £5 each.

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CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 11th were £768, as against £665 for the corresponding period of last year, being an increase of £103. The total receipts for half-year amount to £8,458, against £7,734 in the corresponding period of 1891, being an increase of £724.

COMMERCIAL CABLE COMPANY.—A quarterly dividend at the rate of 7 per cent. per annum has been declared by the Directors of this Company, payable 1st October. The transfer books will be closed on the 20th inst, reopening on the 3rd prox.

NEW TELEPHONE COMPANY (LIMITED).—Share certificates in this Company can now be obtained at the Company's offices, 110, Cannon-street, E.C., in exchange for bankers' receipts.

STOCK EXCHANGE SETTLEMENTS.—The Stock Exchange Committee have appointed special settling days in the following stocks:—Monday, September 19th, Australian Gold Recovery Company's shares, 52,501 to 160,000; Metropolitan Electric Supply Company's £50,000 Five per Cent. Debentures; and have ordered all the above securities to be quoted in the official list.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—A dividend at the rate of 7 per cent. per annum on the preference shares for the six months ended 30th June last will be paid on the 1st October.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 9, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,753.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 7.	Price Wednesday, Sept. 14.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 14. Highest.	Lowest.
			TELEGRAPHS			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	47 48	43 49	5 7 0	Jan., Apr., July, Oct.	48	..
£2,876,140	Stock	25/0	Do. Preferred	87½ 88½	89 90	6 3 7	" "	89⅞	89
£2,876,140	Stock	5/0	Do. Deferred	10¼ 10⅜	10¼ 10⅜	..	" "	..	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	10 ⅜	101½
130,000	£10	3/0	Brazilian Submarine	10¾ 11½	11¼ 11⅜	5 19 2	Mar., June, Oct., Dec.	11⅛	11⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$11½	Commercial Cable Capital Stock	160 165	160 165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10%	17½ 18½	17 18	5 11 1	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3¼ 3⅜	3½ 3⅝	4 16 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	9⅜	..
60,710	20	3/6	Direct United States	11⅜ 11⅝	11½ 11⅞	5 19 2	Jan., Apr., July, Oct.	11⅞	..
400,000	10	5/6	Eastern	14⅜ 15	14⅞ 15⅛	4 6 8	" "	15⅛	14
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16	15⅝ 16	3 15 0	" "	15⅝	15⅜
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	109 112	110 113	3 10 10	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109	106 109	4 11 9	February & August	108¾	107¼
250,000	10	2/6	Eastern Extension	15 15½	15 15½	4 12 7	Jan., Apr., July, Oct.	15 7/16	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 9	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	104	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103 106	103 106	3 15 16	February & August	104	..
180,227	10	3,9	Globe Telegraph and Trust	10½ 10¾	10½ 10¾	4 12 4	Jan., Apr., July, Oct.	10 7/16	10¼
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	15⅝ 15⅝	3 16 10	" "	15 7/16	15⅜
150,000	10	5,0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	18 7/16	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	107 110	105 108	4 12 7	March & September	105	..
17,000	25	37/6	Indo-European	41 43	42 44	5 13 8	May and November	43½	43
88,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108 111	105 103	5 11 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October..	..	..
3,381	£100 Cert.	£1⅜	Submarine Cables Trust 6%	115 120	116 121	4 19 2	" "	..	..
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101 104	100 103	4 17 1	March & September	100½	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1 1½	..	" "	1½	1½
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 9¾	9½ 9¾	6 3 1	May and November	9¾	9 5/16
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
64,242	15	6/0	Western and Brazilian	8¾ 9½	9 9½	6 6 0	" "	9⅜	9 5/16
33,129	7½	1/6	Do 5 per Cent. Cumulative Preferred	6 6½	6¼ 6⅜	5 11 1	" "	6 5/16	6⅜
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾ 3¼	2⅞ 3¼	..	" "	3¼	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
€237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123 128	123 128	5 9 5	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	97 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
x20,000	£1	4½d.	Oriental (11s. paid)	1 5/16 1 3/16	1 5/16 1 3/16	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅜ 4½	4¾ 5	6 0 0	June and December	4⅛	4¼
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13¾ 14¼	13¾ 14¼	4 4 3	" "	14⅛	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13 13½	13¼ 13⅝	4 7 3	" "	13 5/16	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109 111	109 111	4 1 1	January and July ..	110½	109¾
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	9¾ 10¼	10¼ 10¾	..	—	10⅜	10 7/16
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	..	..
8,332	£5	..	House to House Electric	2½ 3½	2½ 3½	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5½	5 5½	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 5¾	5½ 5¾	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16	3 7/16 3 9/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 7/16 5 9/16	5 7/16 5 9/16	..	March	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾ 7¼	6¾ 7¼	..	—	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 5	4 4½	—	—	..	—
18,680	£5	2/6	St. James' and Pall Mall	7½ 8	7¾ 8¼	—	—	..	..
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	—	—	..	..
42,853	5	3%	Westminster Electric Supply (fully paid)	5¼ 6¼	5¾ 6¼	2 8 0	—	6 7/16	6
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/9	Brush Electrical Engineering	2⅞ 3⅛	3⅛ 3⅜	..	..	3 5/16	3
69,996	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2 5/16	2
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼ 5⅜	5¼ 5⅜	6 1 9	January and July ..	5⅜	5⅜
12,139	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	4½ 5½	4½ 5	..	—	4⅜	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜ 2⅝	2¼ 2⅜	—	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	21¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1 5/16 ¼	1 5/16 ¼	..	..	..	..
78,949	5	2/9⅔	Swan United (£3. 10s. paid)	3 3½	3½ 4	9 12 6	May and November	3⅛	..
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	43 45	5 6 8	March and July.....	44¼	41½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July -	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½ ¾	.. ..	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½ 3	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
50,000	£10	½%	City and South London Railway	2½ 3½	2½ 3½	1 8 6	..	..	..

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THE ELECTRICIAN:

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NOTES.

In his presidential address to the Iron and Steel Institute on Tuesday last, Sir Frederick Abel alluded to some experiments which are being conducted by Prof. Fleming and Prof. Dewar upon the electrical resistance of metals and alloys. He gave this as an example of how a pure scientific research may become available for a scientific investigation, which has a direct practical bearing. As might easily be guessed, these experiments are being carried on at the exceedingly low temperatures which may be obtained by the boiling of liquid oxygen. We understand that the specific electrical resistance of metals, alloys, and carbon have been determined between the limits of +100°C. down to −197°C. the oxygen boiling in a vacuum of 25mm. Results of remarkable interest have been found, the increase of conductivity of the pure metals being very great, and there is a most striking difference between the electrical resistance of iron and nickel at the boiling point of water and at the boiling point of oxygen. Some of the experiments are being repeated on a larger scale, but we hope on an early occasion to publish the general results of this interesting research.

The establishment of a National Physical Laboratory for America is being discussed in the *Electrical World* of New York, and the co-operation of several Government departments is being sought. Dr. Webster remarks that Americans are willing to vote thousands of dollars for the construction of lighthouses, but are inclined to ask what the use is of determining the velocity of light with five-figure accuracy. Such "präcisionstechnik" has been suggested as one of the main objects of the institution which has been proposed for this country, and we fear that as long as this is put forward there will be a difficulty in inducing the English Government to do what the Reichstag has done for the Reichsanstalt. Governments may come and Governments may go, but the traditions of the Treasury, fortunately for the taxpayers, go on for ever. Some excellent physical work is done in Greenwich Park, some at the Mint on Tower-hill; a great deal of work of a miscellaneous, but exact, nature is done at Kew, some in Westminster at Old Palace-yard, and some in the kitchen under Richmond-terrace. The economy and greater efficiency which will be brought about by the centralisation of the various branches of the War Office in one building will soon be realised, and it is possible that some such inducement as this might lead to the concentration of the various existing Government laboratories.

Nothing has been heard for some little time of the Gilbert Club, but the main work which it was founded to undertake—the production of an English version of the *De Magnete*—has, we understand, been silently proceeding. The translation in rough form was indeed completed some two years ago, since which date the successive chapters have been under revision by members of the editing committee of the Club. The revised version will shortly be completed, when the work will be published with as little delay as possible.

In connection with scientific clubs having for their *raison d'être* a more or less veiled form of hero-worship, it is interesting to note that the Japanese have gone far beyond us in this respect. Within the precincts of Tokio University there exists, according to the *Japan Mail*, a Newton Club which was originally founded by three undergraduates, Messrs. Fujisawa, Tanaka, and Tanakadate, whose names have since become widely known. The professors, graduates, and students of the mathematical, astronomical, and physical classes of the University are alone eligible for membership. The annual festival of the club is held on the anniversary of Newton's birth, which took place on December 25th, 1642 (O.S.). The constitution of the *Newton Kai* like the idea itself is worthy of imitation; there is no President, a portrait of Sir Isaac Newton presiding instead, there are no written records and no minutes, but plenty of pleasant social intercourse marked by many strikingly original features.

We called attention some little time ago to the deadlock which had arisen in France in the matter of electric lighting in consequence of municipalities having granted broad concessions to gas companies, concessions which are now found to practically preclude the granting of similar privileges to electric lighting concerns. The mania for exclusive concessions, nevertheless, still prevails.

Quite recently the town of Saint-Claude has given a M. Louis Passot the sole right during forty years of running electric wires overhead and underground, in return for which this gentleman binds himself to lay down plant for the supply of current for 10,000 16-c.p. lamps and for motors to the extent of 650 H.P., and in addition to save the town harmless

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in the event of an action by the local gas company. There is the usual saving clause permitting a modification of the contract in the event of the electric light being either superseded or fundamentally improved, but should any necessity arise for the enforcement of the clause it will probably prove as ineffective as have the corresponding clauses in gas concessions. Exclusive privileges of this kind are direct incentives to scamping, especially if lurking in the background there is a possibility of peremptory revocation. It is, therefore, perhaps a matter for thankfulness that there is only one quality of electricity, so that as long as there are stringent regulations with regard to the maintenance of a standard pressure at the consumers' terminals, and heavy fines for breakdowns, some of the worst results of the system of legalised monopoly might be avoided.

In the *Electrical Engineer* of New York an interesting correspondence is being published on the subject of the United States Government purchasing submarine cables abroad notwithstanding that they, like private individuals, have to pay 85 per cent. *ad valorem* tariff on the import. Some of the correspondents, who are all cable manufacturers, seem to think that this duty adds to the cost of the cable to the State, but one points out that the amount is simply paid by one Department to another, and does not really affect the cost to the Government.

Mr. Brixey naturally recommends "kerite" as a reliable substitute for gutta percha, but it is only necessary to say that no one would at present dream of manufacturing a long cable with such an insulator. Another firm, said to be the only makers of gutta percha cables in the States, offers to make and lay seven miles of cable for Lake Huron at $1,500—say £300—per knot. This seems to be a very high figure, as such a cable ought not to cost f.o.b. more than £100 to £110 per knot. In fact, the writer in question admits having offered to make 12 miles of cable at the latter figure, adding "and the English beat us at that." Incidentally, also, he throws some light on the effect of free trade, saying—"It is true there are no manufacturers in the United States capable of making the long ocean cables, as that requires *ships* to lay, as well as factories to make, and since iron wire is the largest item of cost, and that is much cheaper in Europe than in this country, as are also the labour and the ships, the long cables cannot be made here. Of course we could have no Protection on them."

Here is a clear instance of the result of Protection, which, by increasing the cost of materials and labour, gives England a practical monopoly of a large and important branch of manufacture. It appears to be clear that the United States Government are likely to get their cable more cheaply here, to say nothing of the fact that our manufacturers, having a vastly greater experience than the Americans in submarine cable work, are likely to supply a better and more durable article. At the same time the logical outcome of Protection would be to employ local contractors even though the consumer would be the loser by doing so.

Among the early proposals for the industrial application of electricity was one for the purification or refining of iron. The details were never published, and, though the scheme was thrust upon the proprietors of the Gramme patent, they fought shy of it, and only the vague recollection remains of a pair of electrodes thrust in a ladle of molten iron. A M. Fraley proposes to surround a mould with a solenoid, through which alternate currents are to pass while the metal cools. The effect of these currents, according to the inventor, will be to make the structure of the metal perfectly homogeneous, to facilitate the disengagement of gases, and to avoid crystalline formation. The *Bulletin International d'Electricité*, which contains a brief note upon this invention, does not inform its readers whether the process has ever been tried.

Attempts have been made to produce powerful cast-iron magnets by circulating a continuous current round the moulds. If the current is turned on before the metal is poured, it refuses to run into the mould; if it is turned on suddenly immediately after the casting is run, part of the molten iron is ejected, and a large, spindle-shaped cavity is formed. In the absence of any information on the subject, it appears likely that a similar mutual repulsion of the interior parts would take place with alternating currents, and there is little *à priori* reason to expect the other advantages to which we have alluded.

Lightship Communication.—It was stated at the meeting of the Dover Town Council on Wednesday that the East Goodwin lightship is definitely to be telegraphically connected with Dover.

Leeds.—At a recent meeting of the Highways Committee of the Leeds Corporation the plans of the Yorkshire House-to-House Electricity Company were submitted, and were approved of, subject to certain conditions.

The Chicago Exhibition.—The dates for the dedicatory ceremonies are the 19th, 20th, and 21st October. A programme for the final, or actual dedication day, has been issued by the Council of Administration and the Committee on Ceremonies.

Society of Engineers.—The next ordinary meeting of this society will be held at the Town Hall, Westminster, on Monday, October 3rd, at 7:30 p.m., when a Paper will be read on "The Cleansing and Ventilation of Pipe Sewers," by Mr. B. A. Miller.

Heckmondwike.—At a public meeting of the ratepayers of Heckmondwike, on Tuesday, the proposal of the Electric Lighting Committee of the Local Board, that the needful plant for lighting the town by electricity should be laid down, was adopted by a large majority.

The French Telephones.—On January 1, 1890, there were 1,200 miles of telephone lines in France, and on January 1, 1892, 2,850; an increase of nearly 140 per cent. in two years. The total income accruing to the State from this source amounts at present to £220,000.

Electric Lighting in Finnland.—Following the lead of several of the principal Finnish towns, Helsingfors, Wiborg, Tammerfors, and Uhlenborg, for instance, Wasa is about to adopt the electric light. The whole of the plant, including steam engines, is to be suppliedby the Maschinenfabrik Oerlikon.

Carlow.—At Carlow, which Messrs. Gordon and Co. have been lighting for the last 14 months, nearly one-fourth of the total revenue of the Carlow Gas Company has, it is said, been diverted. So serious has the opposition become that on Wednesday night a circular was issued by the Gas Company notifying that any person using electricity would be at once

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cut off from the gas mains. Messrs. Gordon are now preparing to supply the whole lighting of the town electrically. Surely this action on the part of the gas company, if correctly reported, is illegal.

The Walker Engineering Laboratories.—At the meeting of the Iron and Steel Institute on Wednesday Prof. H. S. Hele-Shaw read a Paper describing the Walker Engineering Laboratories, and the scheme of engineering instruction given in them. There are yearly four scholarships of £125 per annum tenable for three years, ten £100 exhibitions, and 20 £50 exhibitions tenable for one year. The total time which a student taking a regular course is expected to work in the college is from 25 to 30 hours per week.

A Cable Museum.—An exhibition of cables has been added to the Imperial Postal Museum in Berlin in a special "cable room." It contains both land and submarine cables, of which samples have been sent from prominent firms in various countries. There are also specimens of the older telegraph cables, demonstrating the havoc wrought by time and sea. Notable among these are specimens of two of the oldest cables, viz., the one laid between Dover and Calais in the year 1850, and the one laid in 1854 between the same two places.

The Mutual Action of Vacuum Discharges.—In a recent contribution on the action of vacuum discharge streamers upon each other, Dr. M. I. Pupin described experiments showing that two electric current filaments in a rarified gas may repel each other in cases where electrodynamic action would produce an attraction. The repulsion did not appear to be due to electrostatic action, but rather to "a strain in the vacuum produced by the peculiar distribution of the gas pressure resulting from the peculiar distribution of temperature."

The Electric Lighting of Bartholdi's Statue of Liberty.—The lighting of the statue of Liberty at the entrance of New York Harbour is to be improved. The Lighthouse Board are thinking of placing two 100 c.p. incandescent lamps in front of each of the 25 windows which form a coronet on the statue. These will be protected from the weather in glazed lanterns with reflectors at the back. Under the balcony of the torch an arc lamp of 2,000 c.p. is proposed, with reflectors arranged to throw light on the face of the statue, and also to throw a beam of coloured light upward.

Chicle as an Insulator.—An account has been received, says the *India Rubber World* of New York, of the production and exportation of chicle in the States of Campeche and Yucatan, Mexico. Chicle, the sap of the sapotille tree, is extracted like camphor, india-rubber and other gum, and the entire output, amounting to something like 50,000lb. last year, is exported to the United States, where it enters into the manufacture of chewing-gum. The market value of chicle is 1s. 3d. per pound. Chicle is an insoluble substance, and it is said to be now used extensively as an insulator, replacing india-rubber.

A Photograph of the Members of the Institution of Electrical Engineers.—A large photograph, measuring 18in. by 28in., has been sent us by Messrs. Barrauds, of Oxford-street. It represents a group of 539 members of the Institution of Electrical Engineers. Nearly 70 of the portraits show the full length, the figures being about 2in. high. The members were photographed separately, and arranged upon an architectural background afterwards. The majority of the portraits are very good, although necessarily small. A key to this photograph has been arranged, but the names are not given in alphabetical order.

Cambridge.—The Secretary of the Cambridge Electric Supply Company writes to correct an erroneous statement which appeared on page 527 of our last issue, which was to the effect that the pipes through which the main cables were to be laid had been buried up without first running the pilot wires, with the consequence that on commencing to lay the main cables it was found necessary to dig up the pipes again. The Secretary states that his Company has not yet commenced to run the main cables, and that the pilot wires were run through the pipes while the work was progressing. We are glad to insert this correction, but may add that the paragraph in question was not published without confirmation from Cambridge.

The Electrical Utilisation of Water Power in Italy.—Within recent years several schemes have been drawn up for the transmission of large quantities of water power to Turin, says *Industries*. Among these there is that of Messrs. Aguidio and Azari, engineers, who have asked for the concession of a large quantity of water power on the Italian side of Mount Cenis. In this scheme it is proposed to generate about 500 H.P. on the spot and transmit it to Turin—a distance of nearly 40 miles—for electric lighting and industrial purposes. This 500 H.P. may be doubled by utilising the fall of the River Cenischia, falling from a height of over 3,280ft. The water, which comes from the top of Mount Cenis, now feeds a basin of 60 square kilometres, surrounded by ice.

An Anti-Induction Device for Telephone Lines.—Herr von Dolivo-Dobrowolsky, in spite of the continuance of the "battle of the phases," has found time to fall foul of the German Post-office authorities, who have thought fit to absolutely prohibit the use of high-pressure electric lines in the vicinity of telephonic circuits. Herr Dobrowolsky's remedy is to place a small induction coil in the middle of any earthed telephone circuit liable to inductional disturbances; in this way the induced currents would neutralise themselves. Another suggestion is to employ two coils, one in the high-pressure disturbing circuit and another in the disturbed telephone circuit, and to so arrange and wind them that the induction of one coil upon the other is made to exactly cancel out the induction caused by the straight portions of the high-pressure circuit.

Electric Power for Tasmanian Mines.—The Australian Rights Purchase Association is about to lay down a large hydraulic plant for the purpose of generating electricity to supply light and power to the mines at Mount Zeehan and Dundas, Tasmania. The plant comprises 262ft. of piping, with an intake of 7ft. 3in. in diameter, gradually reduced to 15in., off which two nozzles are taken of a 4in. diameter each, to play upon a Pelton wheel which has a diameter of 5ft. The working pressure will be 100lb to the square inch, thereby giving 300 H.P. From this station current will be taken by overhead wires to the mines, 10 miles off, where the power will be available for the purposes of lighting, haulage, boring, and pumping. This scheme is said to be the initial one of its kind in Australia, and the largest applied to mining pursuits in the British Empire. The scheme originated from the fact of the extreme cost of mining in the district, owing to the want of roads suitable for the cartage of coal and machinery.

Fibre Graphite.—A new form of self-lubricating bearing under the name of "fibre graphite," has, says *Engineering*, been brought out in America. The bearings are made of a mixture of wood pulp and graphite. The graphite is carefully selected, to be free from grit, and is crushed to an impalpable powder. It is then thoroughly mixed with moist wood pulp, and pressed into moulds having perforated sides, through which the water can escape. After air drying the solidified mass it is soaked in a drying oil and thoroughly baked. The oil appears to serve as a cementing material, and gives the mass some of the toughness and elasticity of linoleum. These bearings have been run for upwards of three years on a line of shafting in the charging house of a foundry, under the coke loft, where they were exposed to dust and to a high temperature. During the whole of this period they have, it is said, run in the most satisfactory manner, and have never once been oiled. They have also been used for the spindles of textile machines running at speeds of 9,000 to 12,000 revolutions per minute, and it is claimed that careful tests show that less work is wasted in friction when these bearings are used than when the spindles ran in gun-metal bearings in the usual way.

Bradford.—The following is a more detailed account of the figures relating to the Bradford Municipal than that given on p. 526 of our last issue:—For the half-year ended on June 30th last the total expenses on revenue account were £1,573 2s. 9d., and the total revenue £3,215. 16s. 11d., leaving a trade profit of £1,642. 14s. 2d. The interest paid on loans out of that sum amounted to £677. 19s. 8d., and the contributions to the sinking fund were £577. 7s. 4d., leaving a net profit of £387. 7s. 2d., as stated in our last issue. The total liabilities at present in respect of loans were £42,341. 18s. 9d. The floating liabilities amounted to £47,836. 4s. Since the com

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mencement of the works there has been paid in interest and on sinking fund account £5,625. 3s. 7d. The trade profit which has been made amounts to £4,825. 12s. 11½d. There was a loss of £1,079. 8s. 5d. on the first half-year's working; in the second half-year the loss was £732. 6s. 11d.; in the third, £315. 6s.; and for the half-year ended June, 1891, there was a loss of £30. 5s. 4½d.; the total loss being £2,157. 6s. 8½d. At the end of December last there was a net profit of £970 8s. 10½d., and at the end of June last the net profit was £387 7s. 2d. If the total net profit be deducted from the total net loss it will show a net loss of £799. 10s. 8d. still to be made up.

Cooking by Electricity.—Messrs. Crompton and Co. are giving close attention to the development of the use of electricity for domestic purposes, including cooking, and in order to bring the advantages of their apparatus before the public, they are showing it at various Exhibitions. Their latest exhibit has been at the Health Exhibition, Portsmouth, in connection with the Sanitary Congress, where they have succeeded in carrying off two prize medals and highest awards, one being for their improved electrical cooking apparatus. Mrs. Knight, the cook employed by the Sanitary Institute to demonstrate the use of the gas and other stoves on trial, prepared food by the electric cookers every day, and considered that the electrical apparatus was not only equal, but superior in many respects to the gas cooking appliances formerly employed. Altogether the innovation of competing with the makers of coal ranges and gas stoves has created great interest. We understand that it is the intention to introduce electricity as a sole cooking power in several large flats in the West End of London nearing completion, where it was formerly intended to install gas stoves. The supply companies will make a special reduction for current used for driving domestic machinery and cooking apparatus. The Health Exhibition at Portsmouth will remain open for a further three weeks.

The Associated Chambers of Commerce and the Telephones and Telegraphs.—At Wednesday's meeting of the Associated Chambers of Commerce the Newport Chamber laid before the conference a resolution condemning the policy of the postal authorities with regard to the telephones, which would, stated the resolution, have the effect of extinguishing trunk lines and would considerably hamper business transactions. The resolution was agreed to. It was agreed—"That, in the opinion of this Association, the extension of direct telegraphic communication between the component parts of the British Empire will facilitate defence, promote trade and investments, emphasise community of interests, and generally stimulate the development and consolidation of the Empire;" and another resolution was passed, on the initiative of the Wakefield Chamber, declaring "that it is unfair to the public that the telegraphic department of the Post Office should, for financial purposes, be treated as a separate establishment, thereby causing unwarrantable delay in carrying out urgent and much needed reforms. That, inasmuch as the postal establishment and its various departments are in their entirety a financial success, the time has arrived when an address of not exceeding six words should be allowed free of charge in all telegrams, and that where practicable telegraphic communication should be extended to the rural districts."

Gamgee's Devaporator.—An apparatus for condensing the exhaust of steam-engines is at work on an experimental scale at Church-street, Millbank, S.W. The inventor, Mr. John Gamgee, does not appear to aim at producing a vacuum, but claims that he returns all the exhaust into the boiler at nearly boiling point. The principle is difficult to understand, as the usual theory of the latent heat of steam is rejected, and the assertion is made that when steam is brought into contact with cold water there is a conflict, and it is this which engenders heat. The steam is passed through a number of tubes filled with water a few degrees below boiling point. It bubbles quietly among balls or other bodies offering a large surface, and is said to be condensed by "surface tension." The apparatus, which we have seen in action, is connected to a small steam-engine, but the arrangement is, we understand, not to scale, and the usefulness of the system cannot therefore be estimated. The action appears to be that of an air condenser, in which the steam is condensed through the intermediate assistance of a mass of water which is kept in motion. A great intricacy of pipes, valves, tanks, &c., and the introduction, by way of explanation, of a glass tube containing ether at a low pressure, boiling by the warmth of the hand, served rather to complicate the matter. This kind of invention ought not to be condemned merely as "unorthodox," and we understand that it is being carefully examined by experts, who, we hope, will be able to explain the working without throwing over any fundamental principles of physics.

The Electricity of Waterfalls.—In a recent number of *Wiedemann's Annalen* some notes on this subject are contributed by Ph. Lenard. Numerous observations and experiments concerning the electricity developed by water falling in drops, jets, or waterfalls have led to the following general conclusions: Drops of water falling on to water or a wetted body generate electricity. Water is electrified positively, air escapes negatively electrified from the foot of the fall. Jets breaking up into spray make the electrification more apparent. Slight impurities in the water diminish the effect considerably. Other liquids and gases also produce electrification, but differing in intensity and sign. The essential conditions of electrification are the concussions among the waters themselves and against the wet rock. The friction against the rock and the fall of the earth potential are of secondary importance, while no effect is due to the water's fall through air and its dispersion in it. The author explains these phenomena by the sudden diminution of the water surface, and the convection of negatively charged air away from the foot of the fall. A jet of water falling from an insulated tank into an insulated pail electrified the latter positively, while the negative electrification of the surrounding air grew to several hundred volts. A steady increase of potential was also produced by drops of water falling at the rate of two per second. Sparks were sometimes obtained from waterfalls, and in all cases the air was found to be negatively charged, though this charge was diminished if air bubbles were driven under water.

The Measurement of High Temperatures.—At the last meeting of the Institution of Civil Engineers for the Session 1891-92 Prof. Roberts-Austen read a Paper on this subject. He pointed out that there were many operations incidental to the work of the engineer involving the use of high temperatures, which should be accurately measured, because a difference of 20deg. at a "bright red" heat might be of vital importance to the success of an operation. Siemens, and more recently Callendar, had shown that very trustworthy results might be obtained by employing the increased resistance of a platinum wire, due to heating it, as a measure of the temperature to which the wire was raised. On the other hand, Prof. H. le Chatelier had perfected the use of thermo-junctions, the electrical equilibrium of which was disturbed by heat, and the measurement of the difference of potential thereby produced, afforded a means of ascertaining the temperature to which the junction was subjected. Prof. Roberts-Austen then described at length his method of rendering the indications of the Le Chatelier thermo-junction self-recording, and he proceeded to show what degree of confidence might be placed in the measurement of high temperatures, incidentally comparing the testimony afforded by an air-thermometer and by a thermo-junction as to the temperatures of highly-heated bodies. The meeting points of gold (1045° C.) and of palladium (1500° C.) were measured by the aid of a thermo-junction, a spot of light from a galvanometer with which the thermo-junction was connected, traversing a scale 30ft. long. Electric pyrometers were, however, in the author's opinion, too costly, and were not sufficiently simple for daily use in works, and it was fortunate, therefore, that a less complicated instrument of sufficient accuracy had also been furnished by Le Chatelier, who had thereby increased the debt due to him by the scientific and industrial world. His new optical-pyrometer, based upon the photometer of Cornu, was described at length, and a series of measurements of high temperatures made by its aid in the furnaces of the Royal Mint, and in various metallurgical works in this country and on the Continent, were given.

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GENERALISATION OF MERCATOR'S PROJECTION PERFORMED BY AID OF ELECTRICAL INSTRUMENTS.

BY LORD KELVIN, P.R.S.

The following mode of generalising Mercator's Projection is merely an illustration of a communication to Section A of the British Association at its recent meeting in Edinburgh, entitled "Reduction of every Problem of Two Freedoms in Conservative Dynamics to the Drawing of Geodetic Lines on a Surface of given Specific Curvature." An abstract of this Paper appeared in *Nature* for August 18th, p. 386.

In 1568 Gerhard Krämer, commonly known as Mercator (the Latin of his surname), gave to the world his chart, now of universal use in navigation. In it every island, every bay, every cape, every coast-line, if not extending over more than two or three degrees of longitude, or farther north and south than a distance equal to two or three degrees of longitude, is shown very approximately in its true shape; rigorously so if it extends over distances equal only to an infinitesimal difference of longitude. The angle between any two intersecting lines on the surface of the globe is reproduced rigorously without change in the corresponding angle on the chart.

Mercator's chart may be imagined as being made by coating the whole surface of a globe with a thin inextensible sheet of matter, sheet india-rubber, for example (for simplicity however imagined to be perfectly extensible but inelastic); cutting away two polar circles to be omitted from the chart; cutting the sheet through along a meridian, that of 180deg. longitude from Greenwich for example, stretching the sheet everywhere except along the equator, so as to make all the circles of latitude equal in length to the circumference of the equator. and stretching the sheet in the direction of the meridian in the same ratio as the ratio in which the circles of latitude are stretched, while keeping at right angles the intersections between the meridians and the parallels. The sheet thus altered may be laid out flat or rolled up, as a paper chart.

What I call a generalised Mercator's chart for a body of any shape spherical or non-spherical, is a flat sheet showing for any intersecting lines that can be drawn on a part of the surface of the body, corresponding lines which intersect at the same angles. One Mercator chart of finite dimensions can only represent a part of the complete surface of a finite body, if the body be simply continuous; that is to say, if it has no hole or tunnel through it. The whole surface of an anchor ring can obviously be mercatorised on one chart. It is easily seen for the case of the globe that two charts suffice to mercatorise the whole surface; and it will be proved presently that three charts suffice for any simply-continuous closed surface, however extremely it may deviate from the spherical form.

In *Liouville's Journal* for 1847, its editor, Liouville, gave an analytical investigation, according to which, if the equation of any surface whatever is given, a set of lines drawn on it can be found to fulfil the condition that the surface can be divided into infinitesimal squares by these lines and the set of lines on the surface which cut them at right angles. Now it is clear that if we have any portion of a curved surface thus divided into infinitesimal square allotments, that is to say, divided into infinitesimal squares with the corners of four squares together, all through it, we can alter all these squares to one size, and lay them down on a flat surface with each in contact with its four original neighbours; and thus the portion of surface given is mercatorised. Except for the case of a figure of revolution, or an ellipsoid, or virtually equivalent cases, Liouville's differential equations are of a very intractable kind. I have only recently noticed that we can solve the problem graphically (with any accuracy desired if the problem were a practical problem, which it is not) by aid of a voltmeter and a voltaic battery, or other means of producing electric currents, as follows:—

1. Construct the surface to be mercatorised in thin sheet metal of uniform thickness throughout. By thin I mean that the thickness is to be a small fraction of the smallest radius of curvature of any part of the surface.

2. Choose any two points of the surface N, S, and apply the electrodes of a battery to it at these points.

3. By aid of movable electrodes of the voltmeter trace an equipotential line, E, as close as may be around one electrode, and another equipotential line, F, as near as may be around the other electrode. Between the two equipotentials E, F, trace a large number, n, of equi-different equipotentials. Divide any one of the equipotentials into n equal parts; and through the divisional points draw lines cutting the whole series of equipotentials at right angles. These transverse lines and the equipotentials divide the whole surface between E and F into infinitesimal squares (Maxwell, "Electricity and Magnetism," § 651).

4. Alter all the squares to one size and place them together as explained above. Thus we have a Mercator chart of the whole surface between E and F.

N and S of our generalisation correspond to the north and south poles of Mercator's chart of the world, and our generalised rule shows that a chart fulfilling the essential principle of similarity realised by Mercator may be constructed for a spherical surface by choosing for N, S, any two points not necessarily the poles at the extremities of a diameter. If the points N, S are infinitely near one another, the resulting Mercator chart for the case of a spherical surface is the stereographic projection of the surface on the tangent plane at the opposite end of the diameter through the point C, midway between N and S. In this case the equipotentials and the stream lines are circles on the spherical surface cutting NS at right angles, and touching it, respectively.

For a spherical or any other surface we may mercatorise any rectangular portion of it, A B C D, bounded by four curves, A B, B C, C D, D A, cutting one another at right angles as follows:—Cut this part out of the complete metallic sheet; to two of its opposite edges, AB, DC for instance, fix infinitely conductive borders. Apply the electrodes of a voltaic battery to these borders, and trace n equidifferent equipotential lines between A B and D C. Divide any one of these equipotentials into n equal parts, and through the divisional points draw curves cutting perpendicularly the whole series of equipotentials. These curves and the equipotentials divide the whole area into infinitesimal squares. Equalise the squares and lay them together on the flat, as above.

If we have no mathematical instruments by which we can draw a system of curves at right angles to a system already drawn, we may dispense with mathematical instruments altogether, and complete the problem of dividing into squares by electrical instruments as follows:—Remove the conducting borders from A B, D C; apply infinitely conductive borders to A D and B C, apply electrodes to these conducting borders, and, as before, draw n equidifferent equipotentials. This second set of equipotentials, and the first set, divide the whole area into squares.

ON THE THERMIC VARIATION OF THE ELECTRIC RESISTANCE OF MERCURY.*

BY CH. ED. GUILLAUME.

The discrepancies which exist between the results of recent determinations of the thermic variation of mercury standards of resistance induced me to take the matter up again with improved electrical apparatus, and utilising the thermometric resources of the Bureau International des Poids et Mesures. A first set of investigations, carried out in the course of the winter of 1889-90, yielded a result which I thought was not free from certain systematic errors. I recommenced the entire work in the following winter, profiting by the experience acquired.

Method.—A mercury standard of about one ohm, brought in succession to different temperatures, was compared with another standard which was maintained at an invariable temperature; the resistances being adjusted so that their positive and negative deviations were approximately of the same amplitude in the temperature interval of the comparisons. The contacts were eliminated by the following process:—By the side of each standard a glass vessel containing a few kilogrammes of mercury was placed; this mercury being kept at the same temperature as that of the neighbouring standard. Let I. and II. be the

* *Comptes Rendus*, Vol. CXV., No. 11.

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standards, and I'. and II'. the corresponding vessels. I arranged the following circuits successively in the same branch of the bridge :—

Bridge—I.—II'.—Bridge, Bridge—I'.—II.—Bridge.

By this means the entire circuit of the rods and contacts remained invariable. In the first investigations the difference between the standards was measured by the resistance of a portion of a brass wire accurately standardised. In the second series each determination was moreover repeated by introducing

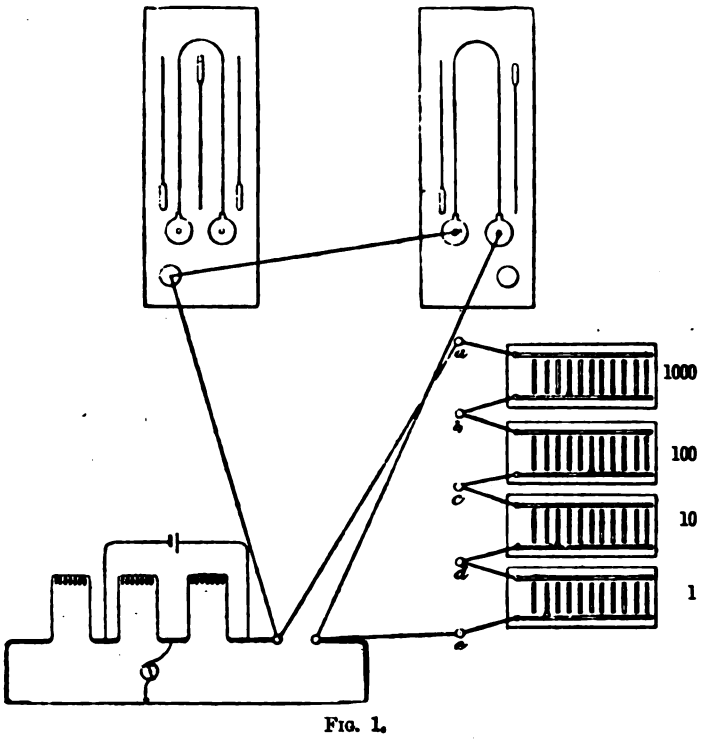

Fig. 1.

as a shunt across the terminals of the bridge a resistance, such as to bring the galvanoscope back to zero. Fig. 1 represents these arrangements. In employing this method the error of comparison depends on the relative error of the shunts multiplied by the ratio of each resistance to its shunt; in my measurements this ratio never exceeded $\frac{1}{30}$. The accuracy sought for being of the order of one in a hundred thousand, it was only necessary that the shunts should be known to about $\frac{1}{3000}$, which presented no difficulty whatever.

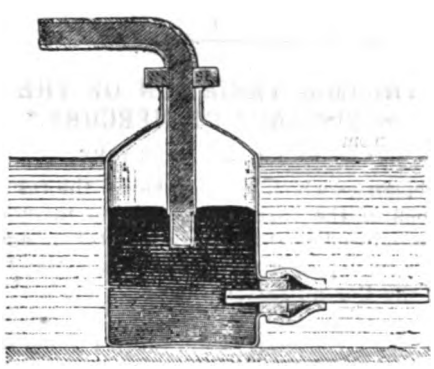

Fig. 2.

Standards and Contacts.—In order not to be too limited in the current strengths to be employed, I chose for the construction of the standards fairly large tubes, containing about 30 grammes of mercury per ohm. In my first investigations the tube opened directly into the terminal cup (Fig. 2), but fearing a disturbing contact effect at the portion of the tube protected by the cork and india-rubber pipe, the first set of cups was replaced in the second series of experiments by some which were provided with a lateral tubulure, allowing the standard to attain along its entire length the temperature of the bath (Fig. 3). At the beginning the contacts were effected by a large copper bar fitted with a platinum capsule, and protected by a glass tube and an india-rubber tube (Fig. 2). I next took to the contacts described by M. Benoit (Fig. 3); and finally adopted a mixed form, which consisted in capping the first contact with a glass cup (Fig. 4).

Comparisons.—In the first set of tests I carried out 37 series of comparisons in water, and 8 series in ice and vapour of water, these latter being with a vertical standard. In the second set I carried out 32 series of measurements by means of the wire, and as many by the aid of shunts. Each series comprised 28 measurements. The measurements were made at about every two degrees between 0° and 61°, and they were distributed in such a manner that I came back on several occasions to the high and low temperatures to eliminate a possible variation of the standards with time, a variation which, I may add, was not observed.

Results.—In the case of my first investigations I shall only give the apparent resistance of mercury in glass as a function of the centigrade scale of hard glass thermometers. The formula I arrived at is as follows :—

$$r_t = r_0 (1 + 0{\cdot}0008726\, t + 0{\cdot}000001057\, t^2).$$

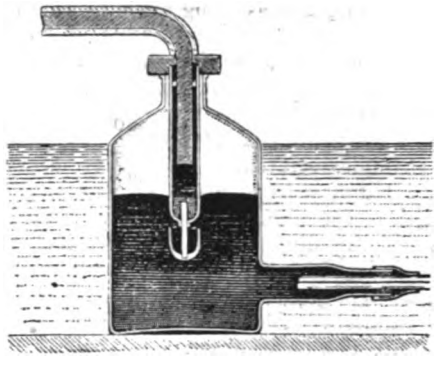

Fig. 3.

Fig. 4.

The complete results of my latest determinations are as follows:—

(I.) Apparent variation of the resistance of mercury in hard glass as a function of the mercury thermometer.

a. By the wire :—

$$r_t = r_0 (1 + 0{\cdot}00087537\, t + 0{\cdot}0000010621\, t^2).$$
$$\pm \qquad 55 \qquad \pm \qquad 89$$

b. By the shunts :—

$$r_t = r_0 (1 + 0{\cdot}00087671\, t + 0{\cdot}0000010469\, t_2)$$
$$\pm \qquad 44 \qquad \pm \qquad 72$$

(II.) As a function of the normal scale :—

a. ..... $r_T = r_0 (1 + 0{\cdot}00088023\, T + 0{\cdot}0000010063\, T^2)$,

b. ..... $r_T = r_0 (1 + 0{\cdot}00088157\, T + 0{\cdot}0000009909\, T^2)$.

Making use of the determinations of MM. Benoit and Chappuis with regard to the expansion of glass, we find the real variation of the specific resistance of mercury as a function of the normal scale to be as follows :—

a. ..... $\rho_T = \rho_0 (1 + 0{\cdot}00088745\, T + 0{\cdot}0000010181\, T^2)$,

b. ..... $\rho_T = \rho_0 (1 + 0{\cdot}00088879\, T + 0{\cdot}0000010022\, T^2)$.

The results obtained by the two methods are very concordant, as one can see by merely inspecting the formulæ, and noting that the values of the terms T and T^2 sensibly compensate each other. The following table gives the values of the apparent resistance of mercury in glass, as a function of the normal scale, calculated from the formulæ II*a* and II*b* :—

—	Values obtained.	
T.	Wire.	Shunts.
0	1·00000	1·00000
10	1·00890	1·00891
20	1·01801	1·01803
30	1·02731	1·02734
40	1·03682	1·03685
50	1·04653	1·04656
60	1·05644	1·05646

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The difference between the last and first determinations justifies my fear as to systematic errors in the latter.

In making use of the above figures for the reduction of experiments relating to the determination of the ohm, we shall find somewhat higher values than those which have been given by most observers, so that the average reduced from good determinations attains, broadly speaking, the value

$$106{\cdot}3 \frac{\text{cm.}}{(\text{microlitre})^{\frac{2}{3}}} \text{ Hg. at } 0°.$$

UNDERGROUND HAULAGE BY ELECTRIC LOCOMOTIVES.

At a recent meeting of the Charleroi Committee of Mining Engineers, M. Clément Baily, engineer to the Marles Collieries, read a communication on electric haulage in mines.

As our readers will be aware, electric haulage by the overhead system has been practised with complete success at a salt mine in Zankeroda, Saxony, for a number of years. Although this plant has demonstrated the commercial advantages of this class of haulage, yet the sparking between the trolley and the conductor, and the rolling wheels and the metals has prevented the application to coal mines, excepting in one instance, as far as our memory serves us. This is at Wharncliffe Silkstone Collieries, in Yorkshire, where a 4 H.P. locomotive was installed by Mr. Albion T. Snell some three years ago. But it seems, according to M. Baily, that there is no gas at the Marles Collieries, and so the Managing Director felt justified in trying electric haulage after seeing the success attained at Zankeroda.

The installation determined on was designed to run two locomotives of 10 H.P., and to be also available for lighting purposes. The E.M.F. selected is said to be 100 volts, and the current per locomotive 30 amperes; but obviously there is some mistake, in the pressure probably. The motors are series wound, with a shunt to the field windings, so as to control the torque for a given current. The gearing consists of two reductions, one being bevelled wheels. The current is said to be collected by *two* small trucks drawn along by the locomotive, we presume them to be little trolleys running on the overhead wire, and apparently the metals are not used as a return. The over-all dimensions of the locomotive are 8ft. long, 2ft. 5in. wide, and 5ft. high, and the total weight with ballast is about 2½ tons. The general dimensions, weight, and design seem to be approximately similar to those of the locomotive recently installed at the Greenside Lead Mines in Cumberland, and referred to in our issue of August 26th, p. 445.

As for M. Baily's deductions they tell us nothing new, indeed we could have foretold them. He says that the grades should be uniform so that the maximum current of the rheostat is never exceeded; light loads are not commercially profitable owing to the relatively great weight of the locomotive; and it is necessary to run at or near to the speed for which the motor is designed. He also finds that the best results are obtained with the field magnets unshunted, *i.e.*, with the wire carrying the whole of the current in the armature. The figures given with reference to the cost of running, &c., are not of interest, since the scale of charges and conditions of working are so different in our country.

The ultimate conclusion arrived at by M. Clément Baily is that haulage by electric locomotives is permissible in non-fiery coal mines, and will be commercially advantageous. We have always been of this opinion, and feel some little surprise that electric locomotives have not superseded horses in many of our English mines.

THE LIVERPOOL OVERHEAD RAILWAY.*

BY J. H. GREATHEAD, M.I.C.E.

The question of improved and more rapid means of transit for passengers is occupying attention in many of the great cities at the present time. With the extension of areas covered the question becomes increasingly pressing. In London it has been under consideration for many years, and during the last Session a Joint Committee of the two Houses of Parliament reported favourably upon a number of proposed underground electric railways of the type of the City and South London Railway, completed and opened for traffic in 1890. In Paris, Berlin, and Vienna, similar railways have been promoted and are under discussion; while in New York, a city long since provided with elevated railways and tramways along most of the main thoroughfares, a Rapid Transit Commission has lately reported in favour of an extensive system of underground electric railways, and in other American cities, notwithstanding the rapid development of electrically worked tramways, additional facilities in the shape of over and underground lines are being considered. This question, then, is an important one for engineers and the iron industries. All the proposed underground lines, are, since the construction of the City and South London Railway, proposed to be made of iron, and that material must necessarily enter largely into the construction of any overhead railway.

The particular railway under discussion is composed almost entirely of wrought iron. The line, now approaching completion, traverses the whole length of the famous Liverpool docks, a distance of about six miles. The extensions north and south authorised last Session go beyond the docks and away from the river in order to give better access between the residential neighbourhood reached by them, the docks, and the heart of the city. With the exception of a short length where the line passes under the Lancashire and Yorkshire Railway coal sidings, the railway is, as its name indicates, overhead, and for the most part just over the lines of the original Dock Railway, which is upon the surface. The Overhead Railway consists generally of plate-iron girders supported upon channel iron columns, and carrying an iron flooring, upon which the permanent way is laid direct, without the usual intervening ballast. With the exception of some half-dozen spans, the line has been constructed without the use of scaffolding, and with very little interference with the traffic, either of the docks or of the streets.

The railway is to be worked by electricity, generated at a station, for which twelve of the arches, forming the viaduct which carries the coal sidings of the Lancashire and Yorkshire Railway, have been appropriated, near the Bramley Moore Dock, and about the middle of the line. At this station are three engines, each capable of working up to 400 indicated H.P., and each driving a separate Elwell-Parker dynamo. The electricity will be carried north and south along the railway by a steel conductor, placed on porcelain insulators, supported upon cross timbers between the rails of each line. Hinged collectors of cast iron, sliding upon this conductor, will make the connection between the motors upon the train and the dynamos at the generating station. The motors are not placed (as on the City and South London Railway) upon a separate locomotive, but are carried by the passenger carriages themselves. A train will consist of two carriages, each to seat 56 passengers, and provided with a motor at one end. The carriages will be so coupled as to give a motor at each end of the train, and the motors will be so connected together as to be controlled from either end by the driver, who will always travel at the front end, changing ends upon arrival at a terminus, and carrying with him a key, without which the motors cannot be operated. All the carriages will be exactly alike, and will contain compartments for two classes of passengers, with through communication from end to end of the train under the control of the guard. A train loaded with passengers will weigh about 40 tons. The trains will be lighted by electricity, and are fitted with the Westinghouse brake, deriving its compressed air from a reservoir on the train, the reservoir being charged after each journey. This system of working the brakes answers well on the City and South London Railway.

The generating station will contain at first six boilers of the Lancashire type, each 30ft. long by 8ft. diameter, with a working pressure of 120lb., stoked mechanically. The engines are horizontal, compound, condensing, by Messrs. John Musgrave and Sons, Bolton. It is intended to commence running with a five minutes' service of trains, but the generating plant is designed to be capable of working a three minutes' service, and the journey from end to end of the railway (inclusive of stoppages) to be performed in half an hour. There are thirteen stations upon the dock portion of the line, and a novel feature on the railway will be a system (Timmis's) of automatic signals at all the intermediate stations, in place of the ordinary signalling arrangements. These signals will be electrically worked by the trains themselves, and considerable saving in the working expenses will result. The total cost of the railway, including equipment, will be about £80,000 per mile. Mr. J. W. Willans is the contractor for the works, and the Electric Construction Corporation are providing the electrical equipment and the carriages. The engineers, Sir Douglas Fox and the author, have been represented on the work by Mr. Francis Fox and Mr. S. B. Cottrell, and Mr. F. Huddleston has had charge of the work (for Mr. Willans), to whom is due the credit for the design of the tilting and swing bridges. It is intended to open the line for traffic very shortly.

* Abstract of a Paper read before the Iron and Steel Institute at Liverpool, Tuesday, September 20, 1892.

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LINES OF FLOW.

"I set Prof. W. THOMSON a prop.," wrote MAXWELL to Mr. CAY in 1865, "which I had been working with for a long time. He sent me eighteen pages of letter of suggestions about it, none of which would work; but on Jan. 3, in the railway from Largs, he got the way to it, which is all right; so we are jolly, having stormed the citadel, when we only hoped to sap it by approximations. The prop. was to draw a set of lines like this— so that the ultimate reticulations shall all be squares. The solution is exact, but rather stiff." This problem MAXWELL wished to solve "in order to calculate the thickdom or viscosity" of a gas. These "reticulations" are familiar to those who have turned over the leaves of his treatise on "Electricity and Magnetism" in the diagrams which placed FARADAY'S lines of force upon a sound mathematical basis. Similar reticulations formed by the intersection of imaginary lines may be found by an effort of the scientific imagination throughout all nature. Wherever there is a flow of heat, isothermal surfaces cut the lines of flow at right angles; in the more gross and mechanical phenomena of sound the direction of propagation is at right angles to the wave front, however that may be contorted, and so, also, with light. In all these and scores of other cases, a set of lines may be drawn "so that the ultimate reticulations shall be all squares." The most well-known

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instance is one to which we have already alluded—electric lines of force and equipotential surfaces. MAXWELL has given a geometrical construction by which these may be drawn with ease; Prof. W. G. ADAMS has shown how the actual lines, if we may use the expression, may be pricked off on a sheet of tinfoil, a most interesting process, which might be used to solve extremely complicated problems of flow. The Rev. F. J. SMITH only last month sent to the British Association a description of a very simple method of drawing lines of force, a method which, in the absence of the author, seemed to be little appreciated and even misunderstood. When graphical methods become more popular, a name will perhaps be found for these curves which in one case we call equipotential surfaces and lines of current-flow, in another isothermal surfaces and lines of heat-flow, in terrestrial magnetism isodynamic and isogonic lines, and in radiation a wave-front and ray.

Difficult as the mathematics may be, which analyse and describe these lines and surfaces by Liouville's differential equations, the curves tell a plain tale by their very shapes; qualitative information this, and subordinate in scientific importance to quantitative, but yet, to a certain extent, complete in itself. Quite distinct from these lines of flow and the surfaces normal to them, there are many other examples of sets of lines which have the property that, however they may twist and turn, their reticulations are all squares. Such are the lines of compression and extension in a girder, contours and lines of slope on a map, and leaving forces and curvatures, the well-known lines of latitude and longitude obey the same general conditions. Most of our readers have probably looked upon lines of latitude and longitude as mere conventional helps in measurement by which the sailor can so conveniently prick his position on a chart, and without which an index to an atlas would be scarcely possible. The reason why lines of longitude always intersect lines of latitude at right angles seems to be obvious, as obvious as that an inextensible sheet of paper when folded and creased presents a straight edge; but equally difficult to explain off-hand. Nor is it our intention to attempt an explanation; to explain would be but to state at some length the exact conditions of the case. But we have to call attention to an article which Lord KELVIN has contributed to our columns, in which he brings forward the remarkable generalisation of the identity of what may be called geodetic lines with electric lines of flow and equipotential surfaces. This is no mere analogy, but the discovery that the same geometrical principle is the basis of the two systems of curves, and the identity of this principle having been shown, a number of corollaries are at once evident. Lord KELVIN has, we believe, "got the way to" several interesting "props." in the train since his journey from Largs in 1865, and his early interest in the present one may have led to this latest application in a most unlikely direction. This problem is interesting in that it is, as treated by Lord KELVIN in the article which will be found in our present issue, purely and strictly geometrical, geometrical indeed in the literal etymological sense. A school of Cambridge mathematician are said to have looked forward to the day when a mathematical treatise should be written entirely in algebraic symbols, without a word of vulgar English language. The reverse is to be found in the present article. Not only is there not a single algebraic symbol, but the geometry is so simple that no diagrams are necessary. The problem is confessedly not apractical one, but it is remarkable that it may be solved by means of a voltmeter and a battery with any desired accuracy. The interest lies in the inductive reasoning by which we pass from particulars to generals. Induction is defined by MILL as the process by which we conclude that what is true of certain individuals of a class is true of the whole class. This, when logically applied, extends our knowledge by important strides from the known to the unknown, compared with the more easy but slow process of arriving at conclusions from experimental premises. An analogy between magnetic resistance and electrical resistance, or rather between magnetic flow and electric current, was described by Mr. KAPP in his Paper on the "Predetermination of the Characteristics of Dynamos" in 1886. He compared a magnet to a battery submerged in a badly-conducting medium, and observed that "it is impossible to say exactly in what manner these leakage currents are distributed." The difficulty lies in the definition of the poles. Prof. ADAMS has shown how lines of flow and equipotential surfaces may be traced in three dimensions, the poles being practically points. The submerged battery is more closely analogous to the magnet and the problem is more difficult. We have already suggested in these columns that the magnetic lines of force and the isodynamic surfaces surrounding a dynamo might easily be drawn, and the ultimate reticulations of these would all be squares.

NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 506.*)

18. Buoyed End Inboard.—As the ship approaches the position where the other end of the cable was left buoyed, a sharp look-out is kept to sight the buoy in time to bear down directly upon it, and should this occur at night it is generally possible with the aid of the search-light to sight it two miles off. As

FIG. 64.—Unmooring Buoy at Sea.

soon as the ship is up to buoy a boat is lowered with four or five hands to unmoor her, this manœuvre being illustrated in Fig. 64 from an instantaneous photograph by Mr. Norman H. Allen, third officer of the Eastern Company's ship the "Electra." Getting the boat up to buoy and hanging alongside is not an easy job in a heavy current or tide way, such, for instance, as rushes through the straits of Lombok and about the neighbouring islands east of Java, near to which the three Australian cables pass. In such strong currents the boat has to be assisted with a line from the ship. To get the buoyed end on board a length of three-by-three rope is passed over one of the bow sheaves from the picking-up drum, and the first thing to be done by the boat's crew is to make this fast to the bridle chain on the

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buoy. The end of the bridle is first detached from the slip hook on the side of the buoy, taken in the boat, and the end of the drum line from the ship shackled on. Meanwhile, on board, the other drum over which the payed-out cable is wound is held stationary by setting up the brake, and then thrown out of gear with the engine shaft. Where there is one engine and one train of gear to both drums the latter can be thrown in or out of gear with the engine by shifting the pinion driving the brake-wheel shaft; and when up to buoy the pinion driving the paying-out drum is thrown out (first, of course, putting brake on) and the pinion on the other drum, used for

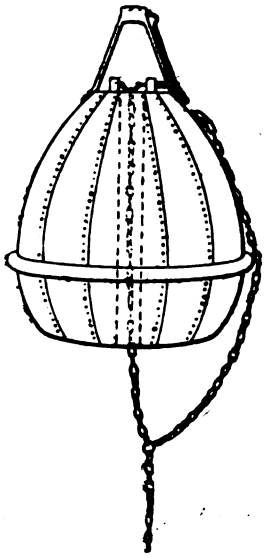

FIG. 65.—Buoy with Central Mooring Chain.

picking up buoyed end, put in gear. Some ships have recently been fitted with a separate engine and separate trains of gear to each drum, giving independent control of each.

On the signal from boat that drum line is made fast to the bridle, the ship heaves in steady and presently takes the whole weight of the mooring chain, leaving the end of this chain on buoy slack. It only remains then to slip this chain, leaving the buoy free and ready to be taken on board again. The ship gives the signal "Knock up" for this chain to be slipped as soon as she has all the strain on board. The slip hook to which this refers has been previously described, suffice to say here that knocking up the washer allows the hook to fall and end of chain to drop free. Another manner of attaching the mooring chain to the buoy a good deal in favour is shown in

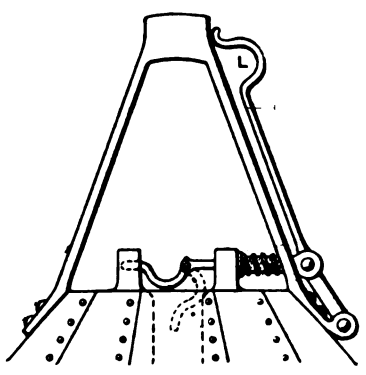

FIG. 66.—Slip Hook for Central Chain.

Fig. 65. Instead of reeving the chain through a ring at the bottom of buoy and attaching end to a slip hook on the side, as previously described, the chain is taken up directly through a tube in the centre, and attached to a slip hook at the top. The latter is constructed as shown in Fig. 66, from which it will be seen that by pulling outwards the lever L at the side the slip hook falls and disengages the chain. The buoy being free, ship heaves in again on drum until the cable appears, when after detaching the mushroom, a sufficient length of cable is hauled in to make the final splice. While heaving in, the strain gradually increases as the cable is raised, and this has the effect of pulling the ship in this direction, thus increasing the strain on the paying out end. To allow for this the brake on the paying out drum is eased as the strain comes on. This operation at the bows is sketched in Fig. 67, the buoy rope being heaved in over one sheave and the payed-out cable being slacked out over another.

This work used to be performed with one drum, before paying out over the bows became a general practice, and the

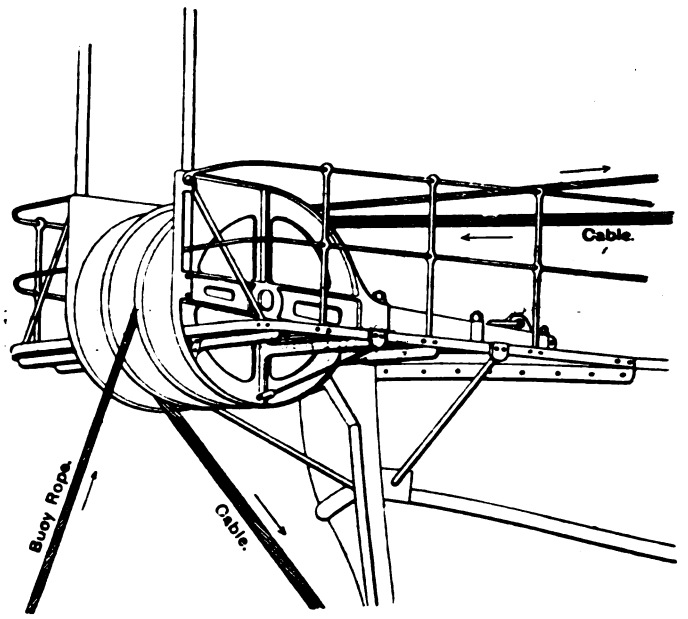

FIG. 67.—Recovering Buoyed End, and Slacking Payed-out Cable.

gear added to suit the requirements. With only one drum the rope for heaving buoyed end was wound round the opposite way to the cable being payed out, and in this manner as much cable was payed out as rope was hauled in. This meant considerably more slack payed out than necessary, and hence the use of two drums forward.

When sufficient length of cable is heaved in to allow for making the splice, manilla slip ropes are made fast (stopper fashion) to both cables at the bows, the other ends of the ropes on which there is plenty of slack being wound several times

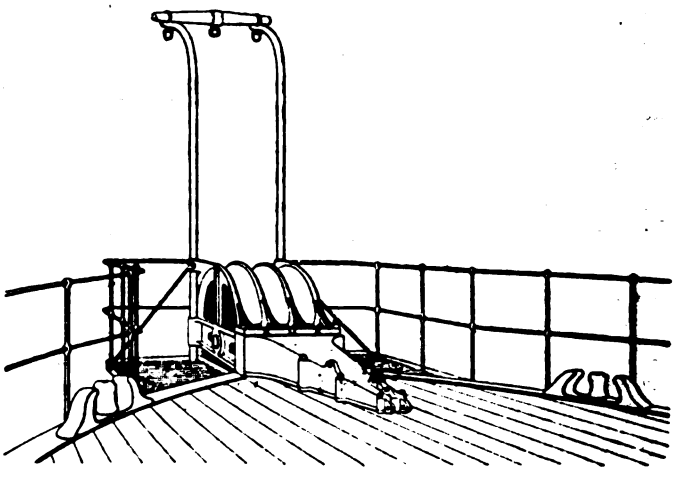

FIG. 68.—Isaac's Triple Bow Sheaves.

round the bullards on deck. These ropes are afterwards used for lowering the splice overboard. In addition to the above the ordinary stoppers are also put on as a matter of precaution, and, this being done, the drums are both slacked away until all strain is taken by the ropes and stoppers, but principally by the ropes. The ship's cable is then cut at a suitable distance for making splice, and the two ends are then at liberty for joining together on deck.

Before dealing with the final splice and completion of the repair, attention may be drawn to the use of a recently adopted

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form of bow, sheaves. It is handy at times to have three sheaves available, one for an extra line from ship as in lowering a splice, and considering the superiority of cast steel in this class of machinery it is not surprising that every opportunity of economising space and weight by its use should be taken. The triple bow sheaves, illustrated in Figs. 67 and 68, have been designed by Mr. Percy L. Isaac for the Eastern Telegraph Company, and are now supplanting the older forms in this Company's ships. The whole is fitted in a cast-steel frame bolted to the deck girders, and takes up less room and is lighter for the same strength than the original double sheaves in iron. The "Electra" was fitted with these sheaves at the time she was built, and the illustration in Fig. 68 is a deck view of the sheaves as fitted to this vessel, while Fig. 67 represents the bows of the "John Pender," also fitted recently with these sheaves. On the latter vessel the new set weighed 4 tons 9 cwt., as against 7 tons 5 cwt., the weight of the original double sheaves which they replaced. It would be, however, a great advantage if what are known as the "whiskers" or cheeks between the sheaves were retained in the new form. The use of these is to prevent the grapnel rope jumping over to the next sheave when pulled sideways by the strain below.

(To be continued.)

GEARING.

BY E. TREMLETT CARTER.

(Continued from page 515.)

Flywheels.

Although not actually part of the gearing between an engine and the machinery driven, yet a flywheel plays so important a part in the distribution of the strains to which the gearing will be subjected, and is designed so much from considerations of the gearing, that it is thought well to devote a section of this series to a discussion of the questions which determine the dimensions of a flywheel.

Whenever the effort exerted by an engine is not equal to the resistance opposed by the moving parts, both being measured at the same radius from the centre of motion, a change of speed takes place. If the torque exerted exceeds the torsional resistance to motion, the rate at which energy is developed is greater than the rate at which it is taken off by the machinery, and a rise of speed occurs; if, on the other hand, it is less than the opposing torque, energy is being taken off at a faster rate than it is being developed, and the deficit has to be made up by the mass of moving machinery, with a consequent fall in speed. In the case of a steam or gas engine driving a dynamo, the fluctuation of energy in the moving parts is entirely due to changes in the effort; the resistance is practically constant. Now, in order that the fluctuation of energy may not strain the gearing, it will be necessary to absorb it, as it were, before it gets to the gearing; that is, a sort of store or bank for the energy must be set up close to the source of fluctuation, into which the fluctuating energy may surge in and out again, keeping the rate of supply to the gearing constant.

The energy which any rotating mass will hold or store depends on its moment of inertia and on the speed at which it may be run; so that the fluctuation of speed for any given amount of energy entering or leaving the mass will vary inversely with the moment of inertia. In the case of a steam-engine, where there is a large amount of fluctuating energy, if it is desired to limit the change of speed to a low figure, it will be necessary to have a large moment of inertia in the crank. The ordinary crank details have not enough inertia, so that the amount required is obtained by keying a heavy wheel to the crank-shaft. In Fig. 11, let the axis ox represent angular movement of the crank, and the axis oy represent on curve E the varying effort exerted by the engine on the crank measured in moments of that effort about the crank shaft centre, and on curve R R the uniform resisting torque. The latter curve is, therefore, the mean ordinate of the former, since each incloses an area which represents the same energy. At the points a and b the effort equals the resistance, but between them the former is in excess, while on either side the latter is in excess. During the first period, from a to b, energy is being absorbed, and the speed comes to a maximum at b; during the period from b to a, energy is being given out by the flywheel, and the speed comes to a minimum at a. The shaded area above the mean line consequently represents the difference in the energy of the moving parts between the conditions of maximum and minimum speed; that is, the fluctuating energy of one cycle of the crank-shaft.

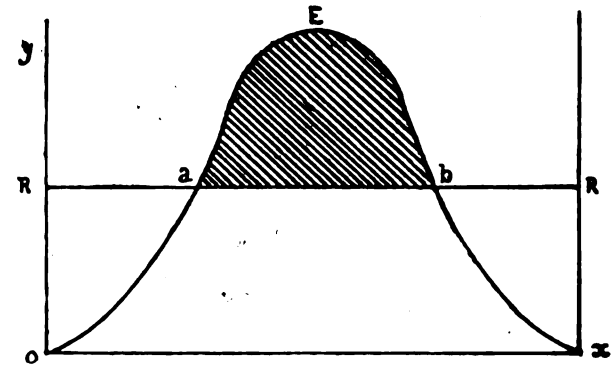

FIG. 11.

Let I represent the moment of inertia of the moving parts, and ω their angular velocity at any instant, measured in radians per second, then the energy of those parts is

$$E = \tfrac{1}{2} . I \omega^2, \quad \text{. . foot pounds.}$$

And since the angular velocity may be expressed in terms of revolutions per minute,

$$E = \frac{\pi^2 . N^2 . I}{1800}.$$

Let ΔE be the fluctuation of energy in foot pounds, N_1 the lowest and N_2 the highest speed during any one revolution; and let N_0 be the normal speed in revolutions per minute.

Then, if I is the moment of inertia,

$$\Delta E = \frac{\pi^2 I}{1800}\left(N_2^2 - N_1^2\right),$$

and,

$$I = \frac{1800 . \Delta E}{\pi^2 (N_2^2 - N_1^2)},$$

whence, in order that the difference between N_1 and N_2 may be small, I must be large. Let p be the percentage variation of speed, then,

$$p = 100\left(\frac{N_2 - N_1}{N_0}\right),$$

and,

$$\frac{N_2 + N_1}{2} = N_0,$$

therefore,

$$I = \frac{90000\ \Delta E}{\pi^2 N_0^2 . p},$$

Engine flywheel rims are usually of cast iron, having a density of 450lb. per cubic foot, and are rectangular in section. If D is the outer and d the inner diameter and w the width of the rim, in feet, then the mass of the rim is—

$$M = \frac{450\, w . \pi (D^2 - d^2)}{4 . g} = 11{\cdot}05\, w (D^2 - d^2).$$

Neglecting the arms, as is usually done, the moment of inertia of the flywheel is—

$$I = M . \frac{D^2 + d^2}{8} = 1{\cdot}38 (D^4 - d^4)\, w,$$

whence, for cast-iron flywheels—

$$(D^4 - d^4)\, w = 6250 . \frac{\Delta E}{p . N_0^2},$$

from which the dimensions of the flywheel rim may be conveniently proportioned. The outer diameter must be chosen with a view to convenience of size and lightness. The larger the flywheel the lighter will be the rim for the same steadying power. It must, however, be remembered that a cast-iron rim should never be run at a greater velocity at the extreme edge

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than 100ft. per second, while 80ft. per second is the usual limit in practice. At higher speeds the centrifugal stress on the metal is liable to cause fracture of the rim. Where the flywheel is also used as a pulley the diameter is determined by the velocity at which the belt or ropes will be run. Belts are not usually run at higher velocities than 3,000ft. per minute, and are often run at lower speeds than this, while ropes are most economical if run at 5,000.

The percentage fluctuation of speed which will be permitted must be settled by considerations of the class of work which the engine will have to do. It must in every case be such that the flywheel will be more sensitive than the engine governor. This is necessary in order that the governor may not oscillate with the fluctuation of speed during each revolution of the engine; a behaviour on the part of the governor which would be satisfactory enough if it did not lag behind that fluctuation in giving steam to the engine, but which, in practice, causes unsteadiness, owing to the existence of such a lag. In electric light engines the percentage fluctuation should not exceed 1 per cent., while in many cases it is less than $\frac{1}{4}$ per cent. Arc lights show distinctly any fluctuation exceeding 2 per cent.; while glow lamps are much more sensitive to variation of speed. When the engine is coupled direct to the spindle of the dynamo, the rotating parts of the machine will act, in some measure, as a flywheel. If these parts are of solid metal, as in the Mordey alternators, there is no injury done by reducing the size of the engine flywheel in proportion to the moment of inertia due to the machine; but if the parts are copper coils they will be liable to severe strains and to become detached if any such dependence on their inertia is made. Where intermediate gearing is used, the moment of inertia of the machine must *never* be taken into account in designing the flywheel.

The fluctuation of energy in the flywheel of a steam engine, when the torsional resistance is constant, depends upon the distribution of steam during the stroke, on the number of cylinders and arrangement of the cranks, and on the speed and power of the engine. A slight influence is also due to the obliquity of the connecting rod, which should be taken into account if that rod is less than five times the length of the crank; it is, however, usually neglected.

In order to determine ΔE, it will be necessary to ascertain the variation of thrust on the piston rod throughout each stroke. This thrust, at any instant, is equal to the effective pressure of the steam on the whole piston *minus* the inertia of the reciprocating parts. Calling F this thrust in pounds, p_e the effective pressure per sq. in., A the piston area in sq. ins. w the weight of the piston, piston rod, cross-head and connecting rod, in pounds, and a the acceleration of the piston in feet per second. Then

$$F = p_e . A - \frac{w . a}{g}$$

the values of a are + during the first half of the stroke and − during the last half. Thus, the reciprocating parts reduce the thrust in the former and increase it in the latter half; causing a more equable distribution of power throughout the stroke.

Taking the motion of the piston as a simple harmonic motion, to which it very closely approximates, we have

$$a = \left(\frac{\pi N_0}{30}\right)^2 . r . \cos\phi,$$

where r is the radius in feet, and ϕ is the inclination of the crank. The maximum value of this is

$$a\,(\max) = r\left(\frac{\pi N_0}{30}\right)^2;$$

whence the maximum inertia resistance of the piston and reciprocating parts is

$$f_{max} = \frac{w . r}{g} . \left(\frac{\pi N_0}{30}\right)^2.$$

In Fig. 12 the curves f and b represent the front and back indicator diagrams of the steam engine, which is to be fitted with a flywheel. The diagrams should be taken at the conditions of maximum fluctuation (*vide infra*). The intercepts of the ordinates, &c., give the effective pressures along the stroke at various equally distant points. These are plotted below in curve (c), the base being, as before, the stroke of the piston. From this must be deducted the reaction of the moving parts, as given in the above equations. If the ordinates, &c., represent pressures per square inch, the quantity f_{max} must be divided by the piston area before deducting this reaction. The deduction is made as follows:—The quantity f_{max} per square inch of piston area is set up vertically at the origin or left side of the base line, and vertically downwards at the extreme right end. A line joining these points gives the curve of inertia reactions, as shown in Figs. 12 and 13. Taking the algebraic difference

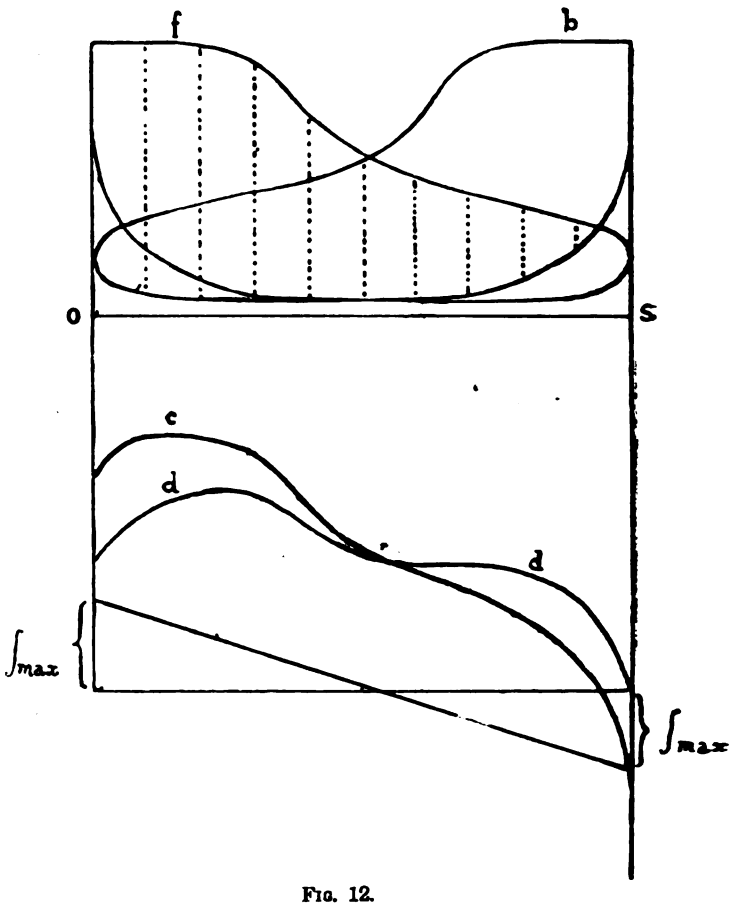

Fig. 12.

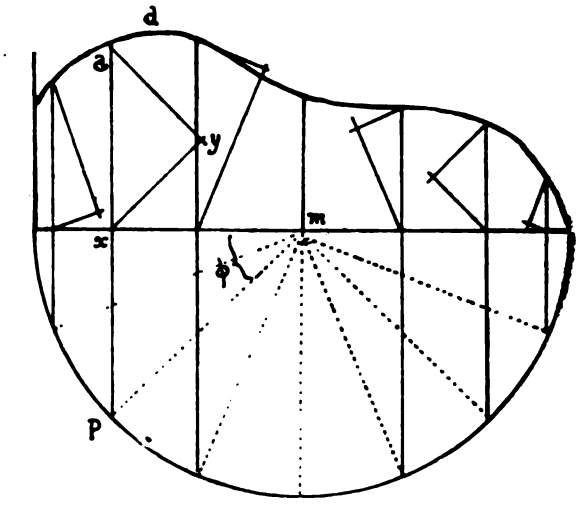

Fig. 13.

between curve (c) and this curve of inertia, we obtain curve (d), the curve of effective thrust on the piston rod. The ordinates of this curve (d) multiplied by the sines of the crank angle to which they respectively correspond would give the ordinates of crank-effort. But the base line of the curve (d) is not one in which equal parts represent equal crank angles, so that it will

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be necessary not only to multiply the ordinates of (d) by the sines of the angles, but also to set off these new ordinates on a new base of which equal parts shall represent equal motions of the crank. To do this graphically, and without the labour of multiplying by the sines of the several angles, the writer has devised the following modification of the usual method:—On the base of the curve d, Fig. 13, construct a semicircle, and divide its circumference into any number of equal parts. In the figure there are eight parts. From these points draw radii to the centre of the circle, and verticals, such as Pa, to the curve d, cutting the base at x. Take the points on the circle in succession and proceed as will be illustrated by taking the point P. We draw through the point x, where the vertical intersects the base, a line, xy, parallel to the radius Pm, and drop ay a normal to this line from the corresponding point on the curve d. The length of the parallel which this normal marks off, from the point x, gives the value of the crank effort when the crank is at the angle ϕ. It will be seen that the operation has merely consisted in graphically multiplying the ordinate ax of the curve d by the sine of ϕ, giving xy as the required crank effort. The operation is repeated for each of the points on the semicircle, and the successive values plotted on a new base at equal distances apart. The new curve which is thus formed is shown in Fig. 14, the ordinates are the values of the crank effort, and the abscissæ are the amounts of crank angle, reckoned from the position at which the crank is on a dead centre. The curve is, therefore, a curve of work; it represents, if its ordinates are taken on the proper scale, the varying work done on the crank pin during one half revolution. It is unnecessary to determine the value of the scale to which this curve has been drawn, and the operation of doing so would be tedious.

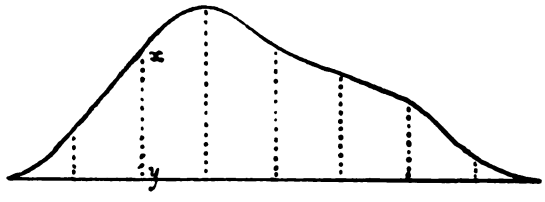

Fig. 14.

We only require to know in what proportion the fluctuation of energy stands to the work done per stroke; and this can be ascertained by means of this curve. Drawing the mean ordinate line, we find a portion of the curve passes above it. The ratio of the area of this portion, above the mean line, to the total area of the curve is equal to the ratio of the fluctuating energy to the work done by the engine in each stroke. If we know the horse-power and speed of the engine, the calculation of this latter is, of course, very simple. The areas may be obtained by a planimeter, or by counting the squares on the squared paper on which the curve should be drawn.

It will readily be seen that, in a single cylinder engine, the position of the points a and b, and the area of the hump above the mean line, will depend on the point of cut-off of steam and on the amounts of back-pressure and compression during the return stroke. In general, the later the cut-off of steam the greater will be the amount of fluctuation of energy; but, after examining a large number of diagrams from actual engines, as well as curves plotted from theory, the writer has come to the conclusion that this rule may be seriously departed from, and that it is impossible to determine any set of coefficients which shall suit every type of single cylinder engine. In some engines the maximum fluctuation was found to occur at a cut-off at half stroke, while others gave an increasing fluctuation as the admission was increased up to full stroke. With compound engines having their cranks set at 90deg., or triple engines with cranks at 120deg., the variation in the amount of fluctuating energy follows a different law; for the earlier the cut-off of steam, below that for which the cylinders are balanced to have equal loads, the greater the fluctuation; and the later the cut-off beyond this point the greater the fluctuation also. This is due to the fact that compound or triple expansions which equally divide the load at a given cut-off will have unequal loads if that cut-off is either increased or diminished. Into the balancing of compound engines and the determination of the fluctuating energy, it is impossible here to enter, as it would take us too far from the subject of gearing. Enough has already been written to show how, from the size of the engine, its speed, and the distribution of steam in its cylinders, the load diagram for each revolution can be obtained.

We turn, in conclusion, to the opposite case which may occur in the design of a flywheel, viz., that in which the effort is constant and the resistance variable. This is the case which meets the engineer when he puts an electro-motor on to certain kinds of work, such as running machine tools. The principle of the calculation is precisely the same as in the case which has already been considered. We must plot the curves of effort and resistance throughout one whole cycle of their changes, drawing the base line on a scale of equal lengths to equal spaces acted through by the forces. We must make a similar calculation of the fluctuating energy, and from this determine the required moment of inertia of the flywheel, finally designing a wheel which shall have this moment of inertia. An example of this may help to elucidate the chief points before we pass on to consider the stresses to which a flywheel is subjected, and the way to deal with them.

Example.—An electro-motor running at 400 revolutions per minute is geared to a machine which is required to run at 100 revolutions. The maximum horse-power to be developed by the motor is 10, and the effort of the motor is constant; but the resisting torque of the machine spindle is 50 per cent. above the mean for the first half revolution of the machine spindle, and 50 per cent. below the mean during the other half revolution. The speed of the machine spindle is required to fluctuate not more than 5 per cent. Design the flywheel, which is to be of cast iron. Following the rule that it is best to place the flywheel as near the source of fluctuation as possible, we shall decide to key it to the machine spindle. It is true that this will involve the gearing in a little heavier strain during starting, but this objection is inferior to the continuous and heavy changes in strain which would result from putting the flywheel on the motor spindle. A little resistance (electrical) in the motor circuit would enable a smooth and easy start to be made.

The mean torque exerted on the machine spindle is—

$$T = \frac{33000 \cdot H.P.}{2\pi N} = 525(\text{lbs.} \times \text{ft.}),$$

whence the maximum torque is—

$$T = 525 + \frac{525}{2} = 788.$$

The difference between these represents the unbalanced torque on the flywheel during the first half revolution or π radians. This difference multiplied by the π radians gives the energy put into the flywheel on account of the fluctuation of speed.

$$\Delta E = (788 - 525)\,\pi = 825 \text{ft. lbs.}$$

From this we calculate the moment of inertia which the flywheel must have—

$$I = \frac{90000 \cdot \Delta E}{\pi^2 N^2 p} = 150 \text{ (gravitation units).}$$

Finding this to be a rather small amount, we can decide to put a disc flywheel on the spindle. Cast iron weighs 450lbs. per cu. ft.; and, if we make the diameter of a cast iron disc wheel equal to 4ft., the requisite thickness will be about 5¼ins.—

$$I = M \cdot \frac{d^2}{8} = \left(\frac{\pi d^2}{4} \cdot \frac{450w}{g} \cdot\right) \cdot \frac{d^2}{8} = 150.$$

If $d = 4$,

then $w = 5\frac{1}{4}$ins. approx.

[*Erratum.*—In the formula for horse-power, on p. 512, *The Electrician*, September 9th, for η read π.]

(*To be continued.*)

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THE ACTION OF ELECTRIC DISCHARGE ON GASES AND VAPOURS.*

BY C. LUDEKING, PH.D.

I have during the past year made a number of experiments on the action of the electric discharge, as furnished by a Ruhmkorff coil, on gases and vapours of various substances for the purpose of establishing, if possible, whether or not electrolysis takes place. There is a qualitative difference in the products of decomposition that collect at the poles, so far as experiment enables us to determine.

The apparatus that I used in the examination of water-vapour was suggested by Prof. E. Widemann, of Erlangen, and may be briefly described as follows:—

A flask, A (Fig. 1), capable of holding nearly 1½ litres, is filled up to the neck with distilled water that has been boiled for 15 minutes immediately previous to the experiment. It is furnished with a singly perforated good cork, carrying a large tube of 8mm. internal diameter, which serves to conduct the vapour from the flask into the sparking-tube C; this tube is also 8mm. in internal diameter. The two delivery tubes passing from it are 60mm. apart. The vapour coming from the flask A divides, in tube C, into two currents, which pass out by the delivery tubes. The electrodes consist of copper wire 3½mm. thick; they have flat polished ends, and are inserted into the tube C gas-tight by means of rubber stoppers, an arrangement that permits of their being set at various distances from one another. They are placed in such positions that they are located in currents of vapour travelling in opposite directions, as will be easily understood. By this means it is possible to ascertain whether or not there is a difference in the gases separated out at the poles, for these may be collected and analysed. The entire sparking tube is encased in an air bath capable of being heated above 100°C., and thus preventing any condensation. The delivery tubes are firmly clamped and held in position with their ends exactly on the same

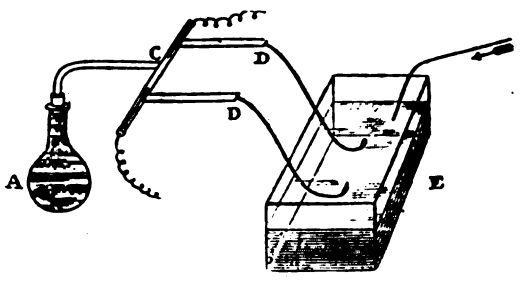

FIG. 1.

level. This is effected by boiling the contents of the flask when only about three-fourths full of water, and collecting the gases given off at once. If the tubes have their ends exactly on the same level, the volumes of gas delivered from each will be equal to one another. By repeated trial it is possible to accomplish this within limits entirely satisfactory. The water in the trough E is maintained at 90°C. or upwards by means of a current of steam, in order to reduce the error resulting from the different solubilities of oxygen and hydrogen as much as possible.

Each experiment lasted from three to four hours, during which time a constant current of steam was given off from the flask and was subjected to the action of the electric discharge, leaping over various intervals between the electrodes. As electromotive power four Grove cells of Browning's make were used. The Ruhmkorff coil was used without condenser, and by its construction could give only a feeble extra current, because the section of the inducing wire was very large and its length very small in comparison with the induced wire. A Geissler tube inserted to remove the extra-current spark did not in any way alter the results obtained, thus substantiating my anticipations; consequently it was unnecessary to resort to the usual means of throwing out the extra-current spark.

When passing the spark at the beginning of an experiment, while there is still air in the apparatus, it is surprising to notice how, in proportion as this is expelled and the atmosphere becomes more and more one of pure vapour of water, the resistance to the passage of the spark increases. It would seem that, just as pure water is a very good insulator, so also pure water-vapour offers very great resistance; in fact, it is possible to obtain sparks three times as long in air as in pure aqueous vapour.

At the conclusion of each experiment the gases were transferred to a eudiometer, and analysed in very much the same way as that used by Perrot (*Ann. de Chim. et de Phys.*, Vol. XLI., p. 161, 1861). This savant conducted a great number of experiments on the electrolysis of aqueous vapour, extending his work over years of time.

In the light of modern theories concerning the cause of electrolytic decomposition, as enunciated especially by Arrhenius, it seemed desirable that these experiments should be repeated. Without entering into detail, I think it will be only necessary to give the results of one of my experiments, which I consider very successful, and which differs from the rest only in better quantitative results, all being alike qualitatively.

In the experiment alluded to, after removal of the hydrogen and oxygen present in proportion necessary to form water, the residues were found to consist of excess of hydrogen—2·6 cubic cm. in the one tube, corresponding to the negative pole; and excess of oxygen, 1·7 cubic cm. in the other, corresponding to the positive pole. From the arrangement of the experiment it is clear that the temperatures of the electrodes must have been the same and constant, *i.e.*, 100° C.

After having assured myself that the above differences in the products of decomposition of aqueous vapour by the electric discharge exist, I experimented next on hydriodic-acid gas, dried, and passed through the same apparatus. It was found that in this instance the decomposition took place very readily, and the positive pole became rapidly covered with iodine, while the negative pole presented a perfectly bright surface of copper. One of the products of decomposition being a solid it was not attempted, of course, to collect the gaseous product. On reversing the current, the poles remaining in the same position and having been previously cleaned, the same phenomenon was again observed, the iodine appearing only on the positive pole. The temperature of sparking was that of the room. But a few minutes were necessary to show the deposition of iodine. By this experiment, in fact, it is remarkably easy to show the distinctive action of the poles in decomposing vapours to a large audience. It is only necessary to fill a large flask having two tubulures, of the accompanying form, Fig. 2 for example, to be found in any chemical laboratory, with dry hydriodic-acid vapour, and then to pass the discharge for, say, fifteen minutes. The electrodes may then be removed and passed round. The proof is thus convincingly furnished that vapours are capable of polar decomposition. When the spark passes through the hydriodic-acid vapour, a great part of the decomposition is of course due to thermal dissociation, and a cloud of iodine vapour rises from between the electrodes at each discharge,

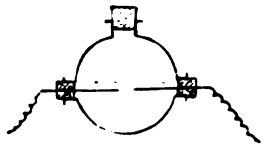

FIG. 2.

rendering this phenomenon very apparent. It is hardly possible to separate perfectly the two modes of decomposition that evidently have place here, nor to understand how they exist side by side.

J. J. Thomson (*Phil. Mag.* [5] XXIX., pp. 358 and 441, 1890) finds that hydriodic-acid vapour is an excellent conductor of electricity. He experimented by passing the vapours of his substances through a platinum tube heated to a yellow heat, and having in it platinum electrodes. It is not impossible that we have here in part a true electrolytic decomposition, and that in amount it is in direct proportion to the conducting power. A pure gas is, I think, not electrolytically decomposed on the passage of the first spark, and is practically a non-conductor. However, by the passage of the first spark there is produced by thermal dissociation a mixture of gases in the pathway of the discharge. This it is that conducts fairly well, so that then electrolysis may take place. The conduction of the current is, therefore, not simultaneous with the passage of the spark, and takes place only during a short time. Consequently, the electrolytic and thermal dissociations are not simultaneous. The partial pressures of the substances electrolysed would thus be reduced; another factor in the promotion of electrolytic conduction.

This may be proved experimentally:—By taking a mixture of the original gas and its components it is possible to effect an electrolytic decomposition by means of the Ruhmkorff coil without the passage of any spark. Such a mixture was prepared, and the electrodes so adjusted that no spark could pass. Then what seems to be an electrolysis was effected, iodine being deposited on the positive pole. That this iodine was not free iodine of the mixture was proved by leaving it out entirely, and making instead a mixture of hydrochloric acid, hydriodic acid, and hydrogen. Then the same phenomenon was observed. We are therefore justified in the conclusion, arrived at also by E. Wiedemann and J. J. Thomson, that the decomposition is in part a true electrolysis after the manner of a Grotthus chain. At least this is one interpretation we may give for the present.

* From the *Philosophical Magazine*, June, 1892.

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We have therefore to do with an imperfect insulator, and the electrostatic energy is gradually transferred between the poles. It is necessary that the electromotive force should be sufficient to decompose the chemical compound, as otherwise no decomposition could have place, but only conduction. It would seem, further, that Thomson's view is correct—that the ease of decomposition of the molecule into atoms is proportional to the conducting power. In that gases at ordinary temperatures are such very poor conductors, it would seem that the conductivity is, as I stated above, the result of dissociation by the discharge and the consequent diminution of pressure. I do not think, with Thomson, that the molecules cannot, while the atoms can conduct. I think I have shown that while pure hydriodic-acid vapour does not conduct to any appreciable extent at ordinary temperatures when pure and dry, it does conduct when diluted with any diluent. Further, that electrolysis of vapours is only possible to any appreciable extent when the mechanical action of the spark has caused such dilution of the pure substance beforehand by dissociating it in part.

Further, I made an extended series of experiments on the action of the electric discharge on the following gases and vapours, viz., carbon tetrachloride, chloroform, carbon disulphide, silicon tetrafluoride, marsh gas, olefiant gas, and coal gas. Where one of the products of decomposition is a solid, it is for obvious reasons not possible to use the apparatus above described to show a polar distribution of the products of decomposition. Now all these substances furnish solid deposits excepting silicon tetrafluoride, which was not decomposed. The hydrocarbons yield deposits of carbon, and therefore it was impossible to find a difference in the gases furnished by our apparatus. However, a remarkable fact was observed, which I believe speaks strongly in favour of actual electrolysis, in the case of hydrocarbons especially. It is that the deposit of carbon for these latter always grew out from the positive pole in a way that would indicate its having been separated out at that pole and not mechanically projected against it. The experiment is most conveniently made with coal-gas, and the sparking done in a cylinder over mercury. The carbon grows from the positive pole in form of a very fine filament, very hard and very brittle, and possessing most excellent conducting power. The film is very thin, indeed thinner, than a horse-hair. On examining it under the microscope it is found to be toothed in a very regular way, the teeth being sharp cones projecting towards the negative pole. Ths deposit could not possibly have been formed by mechanical projection of the carbon. From its character the carbon has not been carried to the pole and deposited there, but is, it seems to me, a true electrolytic separation. In any other way than this it would be difficult to explain the dendritic forms. Another thing that speaks against the mechanical projection supposition is that the filament is a mere slender thread. These forms have the greatest likeness to, and remind one very much of, the dendritic forms of metals that grow out from one pole in electrolysis of metallic solutions, and the current in that case seems to act just in the same way as in the gas. Finally, when a slip of stiff writing paper is placed between the two poles, one does not observe, on passing the discharge, a blackening of the side of the paper turned towards the negative pole, which would certainly be the case were the carbon deposited by projection on the positive pole. There is, however, some carbon, in the form of soot that can be easily wiped off, deposited on the negative pole, though only in small amount. This deposit is entirely different from that on the positive pole both in quantity and quality, and I believe it is a true projection-deposit. Consequently the action of the electric discharge on this gas is not simple, but, as might be inferred, almost *à priori*, of complex character. Firstly and chiefly, we have an electrolytic decomposition by virtue of which the carbon is deposited in a well-conducting form on the positive pole ; and, secondly, we have the dissociation due to the heat of the discharge alone, which in quantity is by far inferior to the former. By the heat of dissociation molecules of carbon are set free and are attracted by both the poles by virtue of their constant static charges.

Concerning the hydrocarbons examined—olefiant gas, marsh-gas, and coal-gas—there is no noticeable difference, qualitatively at least, in the action of the discharge, so that they need not be separately considered. The deposition of carbon takes place more rapidly in proportion as the gas contains a higher percentage of carbon ; thus, under the same conditions in the same length of time, more carbon is deposited from olefiant gas than from marsh-gas. The volumes of the two gases begin to increase rapidly at once on sparking, and very soon double the volume of the original is reached, so that the decomposition is no doubt perfect. This result seems anomalous, when we call to mind that acetylene is formed by the passage of the discharge between electrodes of carbon in an atmosphere of hydrogen. We are forced to the inevitable conclusion, which is rather interesting, that acetylene is not formed when only one of the electrodes is carbon, and that it is necessary that both the electrodes be carbon in order that it be formed. Further, we must infer that it is very probable that acetylene is itself decomposed entirely when the two electrodes are metals or when only one of them is carbon. The increment in volume when marsh-gas and olefiant gas are subjected to the electric discharge is so rapid and striking that it can readily be demonstrated to a large audience in lecture. The carbon separated out from each of these gases is the same in kind and form. Filaments 6 to 8mm. long can be readily obtained in a few minutes, and on continuing the discharge they finally connect the two poles, when the spark ceases. The growth of the filament is entirely avoided by frequently reversing the current.

By the action of the electric discharge on vapour of chloroform no carbon filaments are formed, and chemically the decomposition is not simple in character. There is a large amount of gas formed consisting of chlorine (iodised starch-paper is blued) and hydrochloric acid (the gas is rapidly absorbed in part by water, and the aqueous solution is strongly acid), while a dark red liquid is observed on the mercury of the eudiometer due to the solution of one of the products of decomposition in excess of the chloroform. A further examination of this was not attempted. An exact measurement of the increment in volume of vapour was out of the question, owing to the action of the chlorine formed on the mercury of the eudiometer.

Carbon tetrachloride is decomposed very slowly indeed by the discharge. As in case of chloroform, so here also no carbon filament is formed, while the rate of decomposition is entirely different from that of chloroform. A voluminous yellow deposit is observed on the walls of the eudiometer around the negative pole, and chlorine is set free, as appears by the starch test. The gaseous products of decomposition are not rapidly absorbed by water, as was the case with chloroform. A black deposit is observed on the surface of the mercury. Unquestionably, therefore, it follows from all this that the decomposition of carbon tetrachloride by the electric discharge is by no means simple in character.

When the electric discharge acts upon the vapour of carbon disulphide the volume diminishes rapidly. The vapour of this substance offers an enormous resistance to the passage of the discharge. When the poles are only 1mm. apart only very few sparks pass through, the discharge taking its course outside round the eudiometer through the air, a distance twenty to thirty times as great, a proof that the vapour of carbon disulphide is an almost perfect insulator. In the course of the discharge a grey-blue smoke is observed, which gradually pervades the entire volume of the vapour. Here, then, we have no noticeable evidence of electrolysis taking place. The phenomenon seems to be a heat-dissociation pure and simple. There is deposited on both the poles, not the black conducting modification of carbon as in the case of marsh-gas, &c., but a grey non-conducting matter around which the discharge leaps as it passes from wire to wire. The appearance of the same character and quantity of deposit on each of the poles is, to my mind, conclusive evidence that we have to do here, not with an electrolysis, but with a heat-dissociation alone. I should make it a cardinal requirement for a phenomenon of this kind that the deposits on the poles be symmetrical and of equal amounts. By the heat-dissociation the molecules of carbon are liberated along the entire course of the discharge, and are, as the static charges of the poles are equal, attracted simply in one half of the field to the one pole and in the other half to the other pole. The sulphur molecules liberated at the same time are, on account of the great heat, not deposited on the poles. Indeed in this decomposition, a yellow-brown mass is deposited on the sides of the tube which is nothing else than the sulphur condensed there.

Silicon tetrachloride does not appear to be acted on at all by the discharge. Attempts were made to electrolyse the haloid compounds of mercury in form of vapour. The results were all negative, which may, however, be owing to the great difficulties encountered in carrying out the experiments.

It would seem, finally, that some of the phenomena described are true electrolyses in part. Others seem to be "Thermolyses," that is, the compounds are simply dissociated by the heat of the discharge. The predilection of the atoms thus liberated for electricity of different kinds would make them, like pith-balls, fly to the pole having the charge opposite their own, and thus give the entire phenomenon the appearance in all respects of a true electrolysis, while in reality there is the greatest possible difference. It is very difficult to separate the "Thermolysis" from electrolysis in the experiments I have described, and the phenomena indicate that in most cases described they go hand in hand.

The Electrical Industry in the United States.—A paragraph has been going the round of the Press to the effect that, according to a recent estimate, the capital invested in the electrical industry in the United States amounts to £140,000,000. Of this total, £70,000,000 is allocated to light and power, and £20,000,000 to the electrical supply business.

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ON THE APPLICATIONS OF ELECTRICITY IN THE ROYAL DOCKYARDS AND NAVY.*

BY HENRY E. DEADMAN.

(Concluded from page 541.)

Torpedo and Gun Circuits.

Torpedo Circuits.—When the Whitehead or fish torpedo was first adopted as an element in the offensive armament of ships of war, it was ejected from its carriage by means of an impulse rod or piston actuated by compressed air. The ejection was effected by opening a communication valve between the impulse cylinder and a reservoir of compressed air. As it was necessary that the discharge of the torpedo should be effected from an observing and directing station remote from the torpedo itself, electricity was early pressed into service for effecting the communication between the observer and the firing valve; and in 1879 an electrical arrangement was first fitted for enabling the firing valve to be opened from a distance. The method of ejecting torpedoes from a carriage by means of an impulse rod was soon abandoned however, and the air-gun principle took its place. By this method the torpedo is itself placed in a tube or gun, into which compressed air is admitted behind the torpedo; and the ejection is effected by the expansive force of the air acting directly upon the rear of the torpedo, exactly as the explosive force of gunpowder drives a shot out of a gun. When worked from a distant point the firing valve was still opened by electricity, but on an improved plan. In the earlier ships the batteries were placed below the water-line, and the circuits were complete with main and return wires. Where not protected by armour or not below the water line, the wires were duplicated and kept apart from each other, as greater security against both circuits being destroyed at one time from the same cause. The circuits now used are earth circuits, and are duplicated where exposed, as for instance near the torpedo tubes. Within the last few years powder impulse has been introduced for discharging torpedoes. For this purpose a cartridge containing a small charge of gunpowder is placed in a powder chamber prepared for it at the rear of the torpedo tube. The cartridge is fired by means of an electric current generated in a local circuit, that is, by a battery secured to the torpedo tube itself. This local circuit is momentarily completed by the action of the firing circuit from the observing station.

Gun Circuits.—Electricity is further employed in the Navy for effecting the discharge of guns, either individually at the gun positions or simultaneously in groups, from some protected observing station. So far as the writer is aware, this system was first practically employed about 1874, and the current was obtained by means of pile batteries. These were formed of about 160 elements, consisting of alternate copper and zinc plates, separated by fearnought (a kind of flannel) dipped in diluted vinegar. With these batteries high-tension fuses were used, which were not only dangerous, but frequently failed owing to the difficulty of keeping the circuits free from moisture. From 1874 down to about 1881 gun circuits were fitted as complete wire circuits. Now earth return circuits are adopted, except in some cases of auxiliary circuits which are still complete wire circuits.

Safety Arrangements.—These are highly necessary in the ordinary working circuit, in view of the possibility of the gun being fired prematurely with possibly disastrous results. For instance, the gun might by mischance be fired before the breech block was properly replaced and locked; and to avoid this danger the circuit is broken automatically by the act of unlocking the breech, and the connection is again made automatically in the act of relocking after loading. Again the gun might be fired after the breech block was secured, but before the gun was run out; in which case the energy of recoil would be expended in smashing up the gun mounting. To avoid this the circuit is automatically broken at the front end of the carriage by the action of recoil, and is remade automatically just as the gun again reaches its run-out position. The making and breaking of the circuits are effected by means of rubbing contacts; and while these give assurance against an accidental discharge of the guns, they are not an unmixed good, as they sometimes cause a miss-fire; and a continuous protected circuit without any of these breaks would be more certain and reliable. In the earlier turret ships, especially in the rigged ones, the guns were masked by portions of the ship's structure at certain angles of training. In such cases devices were introduced for automatically breaking the firing circuit at these particular angles. In all the later turret and barbette ships, the turrets or barbettes are placed near the extremities of the ship; and while having a limited arc of training, they are unobstructed in their fire throughout the whole of this arc when the ship is cleared for action. Consequently there is now no necessity for any safety arrangements. In the modern as in earlier ships the full depression of the guns cannot be obtained throughout the whole horizontal arc of training; and the danger of firing into the deck is obviated by an ingenious automatic arrangement, which is in connection with the hydraulic or other mechanism for workihg the guns, and has nothing to do with the electric circuits.

Electric Communication.

The efficiency and safety of a modern war-ship are largely dependent upon the means of communication between the various working parts of the vessel. The officer directing from the conning bridge the movements of the vessel must have the means of instantly transmitting to the engine-room a few pre-arranged signals with regard to the starting, stopping, &c., of the engines; and he likes to have the signal transmitted back to him to assure him that his order has been correctly received, and is about to be carried out. When manœuvring in squadrons, in which his ship has to keep her correct station in relation to the others, he must be able to communicate to the engine-room his orders regarding small variations of speed, say, one revolution more or less over a considerable range of speed. He also likes to be able to ascertain for himself on the bridge the actual revolutions of the engines; and he prefers to do this at a glance, without having to take the trouble to use a watch and count the revolutions, say, for a minute. Where the steering-wheel is immediately under his own eye, as it generally is when steam or other mechanical power is applied for steering the ship, he likes to have an indication on the bridge that the rudder is properly responding to the motions of the steering wheel. Should either of the alternative steering positions below have to be resorted to, he requires a certain means of communicating his orders to the steersman at that position. In addition to the means of transmitting a few pre-arranged signals, he also requires a means of conversing from the conning bridge with the engine-room, with the steering positions, and with a few other places. In action, when the vessel's movements may be directed from a protected conning station, he needs, in addition to the foregoing requirements, to be put in communication with the officers at the various gun quarters, including turrets or barbettes, and also those at torpedo-discharging positions, &c. In fact he requires to be placed either directly or indirectly in communication with every part of the ship where officers and men are stationed. Where only a few pre-arranged signals are required, these intercommunications are effected by means of transmitting and receiving instruments, either mechanical or electrical; while for communications of a general character voice pipes are employed.

About six years ago many complaints were received from ships as to the unsatisfactory nature of the means of signalling and intercommunication; and as many new instruments, chiefly electrical, were then being proposed for use in the navy, a committee was appointed, consisting of naval officers, naval constructors, and marine engineers, of which the writer was a member, to inquire and report upon the whole subject. In the course of the inquiry the views of a large number of representative naval officers were obtained, in order to determine firstly what intercommunication was necessary and best for a ship of war. On this primary question naval officers were not wholly agreed; but there was sufficient accord to enable a standard method to be laid down. In order to arrive at the best means for effecting these intercommunications, the committee studied all the methods that had been previously tried, including those in use in the mercantile marine. They carefully examined and tested many new instruments that were submitted to their notice, and carried out a number of independent experiments.

Voice Pipes and Call Bells.—Among other means of improvement, the committee recommended that all voice pipes connecting stations where there is noise or vibration, and all others if they are over 100ft. in length, should be increased from 1¼in. internal diameter, the size then in use, to 2in. internal diameter; and that with these larger pipes a system of electrical call-bells should be fitted. This plan is now generally carried out in the navy, and has resulted in greatly improving the means of communication. The call-bell arrangement consists of an ordinary push board at the sending station, with the well-known annunciator or drop-shutter instrument at the receiving station; the dropping-shutter indicates the station from which the call has come, and therefore the particular pipe to be spoken through. It is found that with voice pipes communication to places where there is much vibration or noise is not very satisfactory. Many devices have been and are still being tried with the object of improvement. The committee were much impressed with the immense facilities offered by an electrical system of communication; and amongst other things, telephones of different forms were tried in substitution for voice pipes. The results were not such as to lead to their introduction into the ships of the navy.

Telegraphs.—With regard to instruments, though for ship work a mechanical system has some great advantages over an electrical, yet as a means of establishing communication between these instru-

* Paper read before the Institution of Mechanical Engineers, Portsmouth, July, 1892.

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ments at distant stations the electrical system is far and away the best. The many disadvantages of a system of shafting and bevel wheels, led through a considerable portion of the length of a ship, scarcely need to be stated; while the great facilities offered by a simple insulated wire are equally self-evident. The committee therefore recommended that the one mechanical telegraph for communicating orders from the bridge or conning tower to the engine-room should be retained, but that the telegraph for orders respecting speed of revolution should be electrical. Many of these electrical telegraphs have been fitted in the navy; but the reports upon them have not been uniformly favourable, although in some instances they have been highly so. Whether the grounds for the unfavourable reports have always been good and sufficient is a matter of opinion; but at the present time electrical telegraphs in the navy appear to be somewhat under a cloud, so that the field is still open for invention in this direction. The telegraphs already in use are worked by primary or secondary batteries; while a new form has been proposed, to be worked direct from the ship's dynamo.

Other Applications of Electricity.

Submarine Mines.—There are some other applications of electricity in the naval service, which may be referred to without any detailed descriptions. One important application is that to submarine mining, whereby stationary torpedoes or mines are exploded by an electrical current from an observing station on shore, after the position of an enemy's ship in relation to the mines has been ascertained by means of range-finding instruments in two observing stations at a considerable distance apart, but electrically connected. An electrical apparatus has also been designed and experimented with for enabling a boat, without any person in it, to be sent from a safe distance into an enemy's mine-field, to explode and thus render harmless the mines laid there. By this apparatus the boat can be steered, the engines stopped or started, and the countermines dropped where desired, and exploded. In this way an otherwise exceedingly risky operation can be performed without danger to life; and the worst casualty that can happen is the loss of the boat only.

Night Signalling.—Electricity is also applied to night signalling. The ordinary semaphore instrument as used by day is illuminated at night by means of incandescent lamps in front of a reflector, the whole being contained in a wooden box placed a short distance in front of the semaphore arms, which are painted white in order to make them more distinctly visible by night in the rays of the electric lamps. Another system of night signalling has lately been introduced, consisting of four flashing lamps placed in a vertical line at topmast head. The lamps are incandescent with special filaments; and one lamp or more can be switched off at will by an arrangement of switches in the chart-house, where there are also four small lamps which follow the movement of the lamps at masthead. By a preconcerted code the combinations of the lamps are interpreted. This arrangement is intended principally for squadron sailing at night, to convey orders as to altering course, speed, &c.

Gun Sights.—The sights for guns are now adapted for night firing by employing electricity for their illumination. This is effected by means of small incandescent lamps, for which the current is obtained from a primary battery consisting of three Leclanché cells in a box secured to some part of the gun mounting. A switch is also fitted for each sight, having a resistance connected with it, so that the current can be varied at will, and thus the lights can be made more or less brilliant to suit the circumstances.

Examination of Gun Bores.—An apparatus is now supplied to ships for examining the bores of guns. It consists of an inclined mirror supported in a metal frame, which is made to fit the bore, and can be pushed into any part of the bore by a long rod screwed into it. According to the size of the gun the frame carries from one to four 100 c.p. lamps, which illuminate the bore; and by the aid of the inclined mirror a close examination can be made for defects.

Motors.—The application of electricity to motors has not yet gone very far, not so far, in fact, as in some other nations it has already gone or is now going. Of the success of the application to the working of guns, supply of ammunition, &c., the writer is not very sanguine; but if results prove satisfactory the Navy will no doubt quickly profit by the experience of other nations. Electrical science is, as yet, in its infancy, and it promises enormous developments in the near future, so that in a few years operations may be performed by electricity which are not dreamt of now. In any case the British navy will not fail to press into its service every development of science which will increase the efficiency of the nation's first line of defence.

DISCUSSION.

The discussion was opened by Mr. W. H. ALLEN, who called attention to the system followed at Portsmouth for testing steam engines used for the production of electricity. He considered that the measurement of the feed water pumped into a large boiler would not afford the means of determining the efficiency of the engine, and advocated the condensing and measurement of the exhaust steam. Less than four years ago a dynamo to meet the Admiralty requirements weighed close on eight tons, but by reason of improvements made the specification could now be filled on a weight of five tons.

Mr. R. E. CROMPTON said the chief thing to be learned from Mr. Deadman's Paper was that our own Admiralty was very much behind in the matter of electricity. For instance, the projector now in use was that of ten years ago. The French had progressed in this matter, but the Germans had gone ahead of them, while England had been stationary. He had brought out a projector which was half the weight of that used in the Royal Navy, and had all its good qualities, with some additions. In place of solid gun-metal arms they used light steel tubes. The hand lamp they had done away with, and one which was not only automatic but which also cost less had been devised. The German carbons were better than those of France, but the Belgians were now coming to the front with carbons that were quite good enough, and were but half the price usually charged. He was sure that Mr. Willans would have supported the last speaker in his strictures as to the manner in which engines were tested. He thought that the whole question of electricity on board warships was unsatisfactory. Power transmission, as well as lighting, ought to be carried out by electrical means. It was possible to lay down a network of mains so that it would be practically impossible to put the installation out of action. He would substitute electricity for hydraulic power and compressed air.

Mr. CORNER, the chief engineer to Portsmouth dockyard, said that the conditions of testing electric light engines were fully known to all contractors who were invited to tender, and though the limit was 32lb. of water to each horse-power, yet 1lb. in excess of this was allowed in order to cover errors of testing.

Mr. W. H. WHITE said he was one of the Whitehall officials, and therefore he supposed he must be expected to move slowly. For his own part, since electricity came forward as a practical factor in warship design, ten or eleven years ago, he had tried to inform himself on all inventions and changes which had borne any semblance of promise, and he had endeavoured to utilise all advances. Outside the personal question, however, the Admiralty made it a ruling principle to test everything that showed any promise. Mr. Crompton, as an electrician, started with the axiom that electricity was the best for everything. The proposition had, however, been disputed by those whose opinion was certainly worthy of consideration; in fact, the majority of those entitled to speak on the subject with greatest weight most decidedly preferred hydraulics. It was also a serious matter to introduce radical changes in so complex a machine as the Navy. That was a very practical consideration which those who were actually responsible dare not forget. For his own part he had seen a warship in which all operations were performed by electricity, and what he had there learned had not been of a nature to force him to the same conclusion as Mr. Crompton. He had, however, been much struck by the arrangements carried out, and he thought that such a thing might come in the future, but at the present moment the time had not arrived. Some of the officers in the service best acquainted with these matters, those who were connected with the torpedo side, had expressed the greatest doubt as to the advisability of using electricity to the extent advocated by Mr. Crompton. There was one point they must not forget in estimating the respective merits of electricity and the other means of transmitting power. That was the question of fuel consumption, always a vital point on shipboard.

A BELGIAN 500 HORSE-POWER DYNAMO.

We are indebted to *L'Électricien* for the following particulars relating to a 500 H.P. generator which has recently been built by the Société Internationale d'Électricité of Liège for La Fabrique d'Armes de Herstal, where the current is employed mainly for motive purposes.

The dynamo is a shunt-wound Gramme-ring, multipolar machine, coupled direct to a compound condensing engine by Van den Kerchove, which runs at 166 revolutions. The field-magnet system forms a crown, and consists of 10 sections bolted together. There are 20 poles, and 6mm. clearance is allowed. The sections of the field-maguet system complete with their coils were first assembled, and then pulled to pieces again, to leave space for the building of the armature, the huge proportions of which necessitated its construction *in situ*. The method of constructing the armature was as follows:—A hub was keyed on to the shaft under hydraulic pressure, two cast-iron cheeks being then put on; the periphery of these cheeks being notched with 100 indentations. The diameter of the armature is 4·8m. (15·8ft.). The core is composed of iron sheets 7mm. (27·5mils.) thick, insulated from each other by paper, the total length being 40cm. (16in.), and the depth being 13cm. (5·2in). The core discs are not only kept in place by pressure, but are traversed by bolts and cross-pieces to the number of 50 each.

The armature conductors are composed of copper strips 4 × 5mm., insulated with cotton and shellac. On the external circumference there is only one layer per turn; but inside, in the spaces left by the notches in the discs, the wires are two deep. The total number of turns on the armature is 2,400. There are two commutators, each 2·5m. (8ft. 3in.) in diameter, to which alternate coils are brought. The armature windings are stayed against centri-

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fugal action by phosphore-bronze hoops, the peripheral speed being 16·75m. per second (3,300ft. per minute). The current is collected by 80 metallic strips, which can all be actuated simultaneously.

The maximum output of the machine is 2,440 amperes at 125 volts. The current density in the armature conductors is 3 amperes per sq. mm. (1,935 per sq. inch), and in the shunt coils 1·6 amperes per sq. mm. (1,032 per sq. inch).

The choice of a metal for the field-magnets was not arrived at until after numerous tests. Wrought iron was too expensive, and cast iron did not present a satisfactory magnetic quality. Extra-soft steel, from the Angleur Steel Works, was finally decided upon; its magnetic permeability was found equal to that of commercial soft iron, and it could be cast.

The weight of the steel shaft is 10 tons, that of the iron of the armature alone 6 tons, and that of the cast-iron discs 8 tons; the weight of copper on the field-magnets is 2 tons, while that on the armature amounts to over half a ton.

ELECTRIC LIGHTING AT HANLEY.

The following is a condensed summary of the contract with the Brush Electrical Engineering Company which has just been entered into by the Hanley Town Council:—

Four Lancashire boilers, each 28ft. by 7ft., to generate steam at a pressure of 140lbs. Five vertical compound condensing engines, three to be of 200 I.H.P., and two of 100 I.H.P., at a steam pressure of 120lb. Five alternators, three to be of 100 units, and two of 50 units, the machines to be driven from the engines by ropes. There is to be a separate vertical engine and dynamos for the exciters, and a separate compound engine for the air and circulating pump and surface condenser. Each alternator, each exciter, and each circuit is to be equipped with complete switchboard. The primary mains are to consist of two lines of cast-iron socket pipes, into each of which a concentric cable will be drawn, these to be run from the generating station on canal side to the compulsory area, together with a third line of cast-iron pipes for future requirements. There is also to be a primary ring main of the same character, embracing five transformer points and fifteen transformers within the compulsory area. The low-tension distributing mains to be laid throughout the streets scheduled in the compulsory area comprise a small cast-iron trough with cast-iron lid, with two separate insulated cables embedded therein in bitumen. Total of this contract, £13,964.

With regard to the street lighting within the compulsory area the contract includes twenty 2,000 n.c.p. Brush direct current arc lamps and posts, one switchboard, and two dynamos, each capable of developing 12,500 watts; two vertical compound steam engines, having cylinders 6in., 10in., and 8in. stroke; 2 miles 640 yards of copper conductor, insulated with vulcanised rubber, and braided and drawn into wrought-iron pipes, with all the necessary fittings, as specified; total, £1,796. Total for general supply and street lighting £15,760.

Abstract of Tenders Received.

The following schemes utilised Canal side for the generating station, where the value of the land is 6s. per square yard, and the distance from compulsory area 840 yards:—

High Tension Continuous Current Plant with Continuous Current Transformers to a Low Tension Distribution in the Compulsory Area.

1. The Electric Construction Corporation (Ltd.), London £21,979

High Tension Alternating Current Plant with Transformers on Customers' Premises.

2. Messrs. C. A. Parsons and Co., Newcastle-on-Tyne .. £19,100

High Tension Alternating Current Plant, with Transformers at Sub-Stations and Low Tension Distribution in the Compulsory Area.

3. *Permission to publish withheld* ....
4. Messrs. J. G. Statter and Co., London £18,517
5. Messrs. J. E. H. Gordon and Co. (Limited), London.. 17,286
6. Laing, Wharton and Down Construction Syndicate (Limited), London 15,690
7. Westinghouse Electric Company (Limited). London.. 14,526
8. Brush Electrical Engineering Co. (Limited) London (accepted) 13,964
9. Messrs. J. D. F. Andrews and Co., London 10,115

The following schemes utilised the land in Percy-street for the generating station. This land is within the compulsory area, and is in the centre of the town, and valued at £3 per square yard. There is no water for condensing, and coal must be carted:—

Low Tension Continuous Current Plant with Accumulators.

10. Messrs. Paterson and Cooper, London £20,500
11. Messrs. Johnson and Phillips, London 19,350
12. Electric Construction Corporation (Limited) 17,514
13. Messrs. Sharp and Kent, London 14,150
14. Messrs. Crompton and Co. (Limited), London 13,000

Low Tension Continuous Current Plant without Accumulators.

15. Messrs. Siemens Bros. and Co. (Limited), London ... £15,430
16. Manchester Edison-Swan Company (Limited)..... 12,140
17. Messrs. Woodhouse and Rawson United (Limited)... 8,750

The following schemes utilised the land adjoining town yard for the generating station. Here the land is valued at 6s. per square yard, and the distance from the compulsory area is 400 yards. There is no water for condensing, and the coal must be carted.

18. Messrs. Siemens Bros. and Co. (low tension) £18,350
19. Messrs. Johnson and Phillips (high tension)..... ..... £17,550

All tenders were for a total output of 400,000 watts, except that of Messrs. Woodhouse and Rawson, which was for 300,000. The horse-power varied from 450 to 800. All the low tension schemes except No. 12 were on the 3-wire system. Nos. 2, 13, 14, 19 specified Willans engines, and Nos. 1, 3, 4, 15, 18 horizontal engines, while No. 2 specified steam turbines coupled direct to alternators. Nos. 1 to 9 were all condensing schemes. No. 9 did not include for transformers.

The tenders invited for street lighting were for 20 arc lamps distributed in the compulsory area. Some tendered for an entirely separate plant, the arc lamps being lighted and extinguished from generating station. Others tendered for alternating current lamps controlled from a transformer station within the area; and some tendered for no separate system at all, but for taking the electricity from the nearest general supply cable, and requiring the lamplighter to go round to light up or extinguish. In each of these classes there were variations, some including both arc lamps and posts, some including lamps but not posts, and others excluding both. No fair comparison could, under these circumstances, be made, and we do not, therefore, publish these tenders.

LEGAL INTELLIGENCE.

Cox, Robinson and Company.

At the Liverpool Bankruptcy Court last week an inquiry was held in this matter. The debtors carried on business at Strand-street, Liverpool, as electrical engineers. The joint statement of affairs showed liabilities £1,627, and assets £873, excluding £42 due to preferential creditors. The sum of £430 was set down as value of patents; £250 stock in trade, and £125 book debts. Their cause of failure was stated to be loss in developing sundry patents. Charles Walter Cox said that the partnership commenced in September, 1887, each partner contributing equally to the stock, working tools, and electrical apparatus, valued at £250. He was to find working capital as required by the business, and between 1887 and 1890 paid in about £800. In 1890 they patented an electric invention for advertising purposes called "The Levonia Flashing Letters," and an agreement was entered into by the Empire Varieties Company, Leicester-square, London, for working a magnetic apparatus in connection with the "show," of which, under agreement, details could not be given. The inquiry was adjourned.

A list of creditors under this failure will be found in our Trade Notes this week.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 9, 1892.

The Boston West End Street Railway.—So much has been written about the gigantic power station of the West End Street Railway in Boston that very little remains to be said. It may be of interest, however, to English readers to know that the first half of this plant—which has been in process of construction for three years—is completed and is now in daily operation. According to the plans which chief engineer Pearson has formulated, the ultimate steam capacity of the plant is to be 26,000 H.P., of which amount 12,000 is now installed. The engines are of the Reynolds-Corliss type, and were built by the E. P. Allis Company, of Milwaukee, and were designed to develop 1,000 H.P. under the most economical conditions, and work up to 2,000 H.P. at a maximum. The guarantee of the builders is that under a load of 1,000 H.P. the steam consumption should not exceed 13 pounds per H.P.H. It is reported that careful tests show that even less than this amount is consumed. The engine cylinders are respectively 23, 36, and 52in. in diameter, and have a 48in. stroke. The steam pressure in the three cylinders is respectively 160, 35, and 5lbs. The speed for which the engines are built is 72 revolutions per minute.

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Electric Traction at St. Louis.—As indicating the rapidity with which the electric railway industry in this country is growing, it may be stated that the General Electric Company recently booked an order for about 80 car equipments for one of the principal railway lines of St. Louis, Mo. This additional equipment for St. Louis will place the entire street railway system of the city under the electrical system of operation. It is said that the General Electric Company will furnish for this order the Thomson-Houston system of street car motors. An interesting feature of the equipment is the specification that the generators furnished shall be of 800 H.P., these will be by far the largest generators in use in any plant in this country. The type to be used will probably be that now in service in the West End station in Boston, which is a four-pole machine with Gramme ring armature, using four brushes.

The Trolley System in New York.—The advocates of the trolley system still continue to urge its adoption for the street railways of the residence sections of New York, and it is more than likely that before twelve months have passed franchises will be secured by some of the New York companies to operate their horse-car lines by the overhead trolley system.

The Chicago Exhibition.—The only important piece of information regarding the electrical exhibits at the World's Fair which has been given out during the present week is the announcement that the collection of relics, paintings, and other mementoes of the laying of the Atlantic cable, which were bequeathed by Cyrus W. Field to his children will be kept together and placed on exhibition at the World's Fair in 1893. It is said that they will form a part of the Western Union Telegraph Company's exhibit.

CORRESPONDENCE.

THE MAGNETIC BALANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On reading up the latest numbers of *The Electrician* I find a note (Sept. 9) referring to the instrument exhibited at the British Association and criticising the imperfect magnetic contact with the ends of the test sample, out of which an uncertainty is said to arise. To prevent misunderstanding I beg to state that this uncertainty does not affect the principal measurement, viz., that of induction by tractive force (as it would in the "divided-ring" or "permeameter" type) because the motion has been for this very reason transferred to the cheeks of the purely instrumental air-gaps, the invariable configuration of which is secured with great care.

On the other hand the shearing will certainly be somewhat affected by the nature of the contact; however, this only enters as an error, the variations of which I think will be negligeable with reasonably careful end-squarings, since the reluctance of the other instrumental parts is much larger than that of those contacts. I intend to have the balance still further tested, and this point may be easily settled in a few trials, *e.g.*, by interposing thin paper and measuring the effect produced thereby. As a matter of fact I never intended anything more than an approximation to, say, 2 or 3 per cent.; if higher accuracy be aimed at the precept may be given:—Don't be in a hurry, turn an ellipsoid and use a magnetometer.

As regards the railway-buffer contact or the artificial brass-gap you propose, I believe it would be quite as difficult to ensure the reproduction of exactly the same configuration in every case as it now is, so that the uncertainty about the shearing would not be diminished. The instrumental air-gaps are both ½ mm.; I have resisted the temptation to still further reduce them, thereby diminishing the shearing, because the relative effect of any variation of dimensions would increase. And no amount of workmanship could entirely prevent such slight variations occurring through changes of temperature, &c.—Yours, &c., H. E. J. G. DU BOIS.

Physical Institute, Berlin University,
Sept. 19, 1892.

THE KELWAY SYSTEM OF SIGNALLING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The important Article, Semaphore *v.* Morse, in your last week's issue contains a statement respecting the "Kelway" system of signalling which, in justice to myself, requires some explanation. The statement is that "*the only possible advantage of so cumbrous a device is, that it is legible by a perfectly uninitiated person. It was difficult indeed to see what use could be found for it*, but an opportunity was afforded during the recent elections, when the system was used to signal the results to a crowd outside the National Liberal Club." The italics are mine.

The board upon which the incandescent lamps were arranged, exhibited at the Naval Exhibition last year, at the Crystal Palace, and, recently, at the National Liberal Club, was hastily made and did not correctly represent the arrangement devised for actual use in signalling at sea and elsewhere. In practice the lamps will be fixed on a frame composed of metal tubes sufficiently large to carry the wires; the whole presenting to the wind and enemy's fire a considerably smaller superficial area than existing "service" search-lights, even when a six-foot letter is used.

As to the advantages of my system, I venture to claim that the mere fact of the signals being readable by uninitiated persons, as demonstrated to thousands at the above-named places, stamps the invention as one deserving the serious consideration and support of all interested in the important subject of night signalling, as it cannot truthfully be denied that the enormous sums already expended upon signalling have failed to produce satisfactory results in the Navy, as the following cutting from the *Times* of the 30th July last proves:—

"Last night the inhabitants of Penzance were gratified with a display of search-lights by many of the ships, a general order having been given for search-lights to be ready at 10 o'clock. Not a few of the ships interpreted this as a permission to begin working their lights at the hour named without waiting for a further signal from the flagship. They were, therefore, ordered to extinguish their lights and wait for further orders. *The fact that more than an hour elapsed before this cancelling order was received, understood, and executed by some of the ships anchored at a distance from the flagship would seem to point to some deficiency in the signal department of the mobilised and newly-commissioned ships*, about which I shall, perhaps, have something more to say before the manœuvres are over."

Again, on the 9th August last, the same correspondent wrote:—

"In the former letter I mentioned the difficulty experienced by the flagship in getting its signals taken in and answered by some of the ships stationed at a distance. This difficulty has again been more than once experienced since we left Killery Bay, especially in the case of night signals transmitted by means of the flashing lantern. . . . This deficiency in the signalling department is a serious evil in any case, and might in some cases be a fatal one. . . . I am inclined to think from what I have heard and seen that the methods in use at the School of Signalling now established by the Admiralty are too theoretical, and not sufficiently practical. . . . Year by year I have noticed the same faults and listened to the same complaints from officers of the signal department. . . . There seems to be in some quarters a tendency to underrate the importance of rapid and accurate signalling, to suppose that the rating makes the signalman, who has to learn the very rudiments of his practical duties after he has joined his ship."

Your recognition, Sir, of the importance of the subject is evidenced by the space afforded to the article "Semaphore *v.* Morse," and if you will favour me with the insertion of this communication in your influential journal, emphasis may be given to the fact that a simple and reliable system of signalling is available on sea and land.—Yours, &c.,

London, September 21, 1892. C. E. KELWAY.

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EARTH-CURRENT STORMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Following up Mr. Preece's Paper on "Earth-Current Storms," recently read by him before the British Association, and his appeal to observers abroad, I willingly send you herewith a few details of my experience in this part of the world during one of the earth-current storms between the 12th and 17th July last, which may perhaps be useful when associated with similar reports from various other stations on or about the same date.

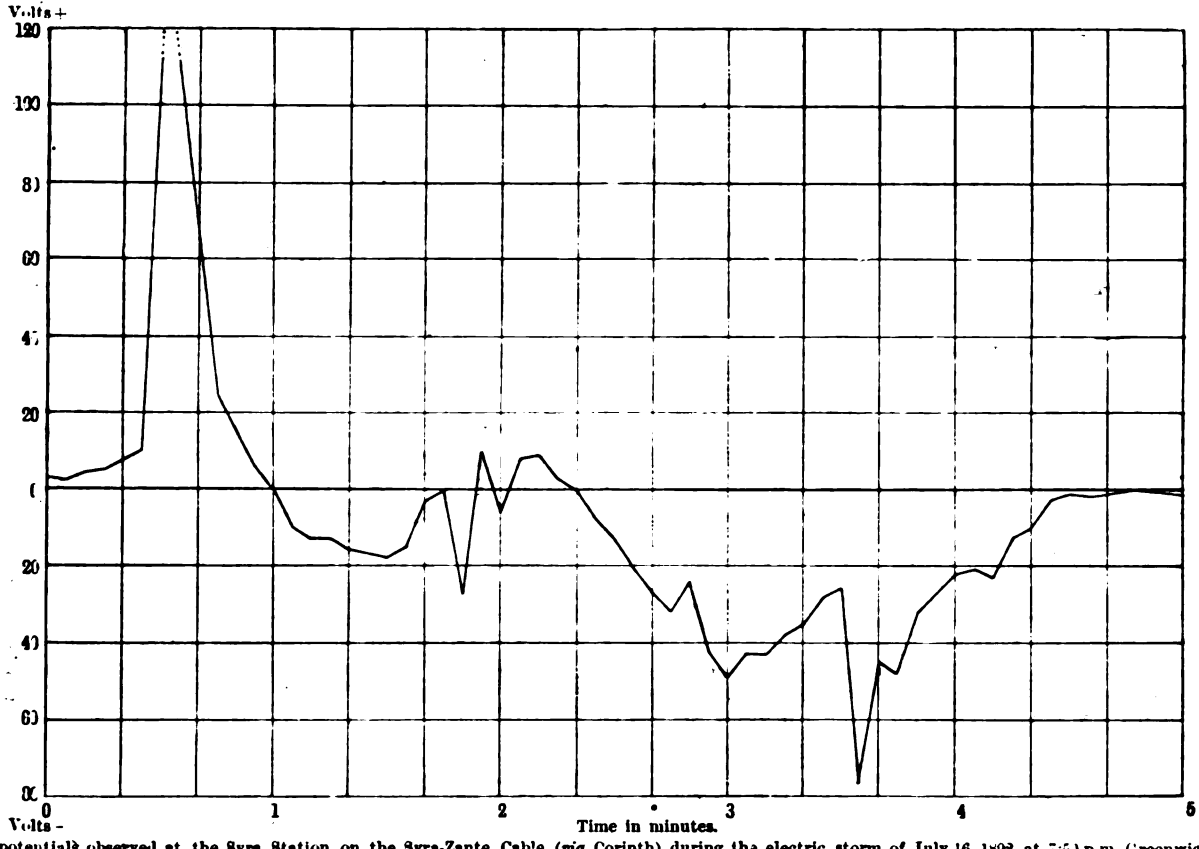
It was at 5:50 p.m. (Greenwich time) on the 12th July we first observed the effect of the abnormal earth currents by the siphons of our recorders being suddenly sent flying off the slip, and the coils remaining deflected for about fifteen minutes, during which period all work was suspended. One of our morse circuits to Smyrna was also rendered unworkable. On this occasion Athens reported a slight shock of earthquake. During the 13th, 14th, and 15th July the earth currents were noticeable, but their intensity was not such as to interrupt the working of any circuit; however, from noon to 8:30 p.m. (Greenwich time) on Saturday, 16th July, we were in a state of confusion, and at times all our circuits were ungovernable, and the traffic suspended in consequence.

As Mr. Preece justly says, at such moments our attention is given to getting off the work and not for experimenting, but at 7:50 p.m., when nothing could possibly be done, and the electric storm appeared to be at its zenith, I took the least important circuit and which seemed to be the most affected, for the purpose of obtaining the observations which are plotted in the accompanying curve. The opposite signs of the potentials were accepted as compared with the position and negative currents of a voltaic battery. It was reported at the time that all the lines in Greece, Italy, and South Russia suffered from the severity of this storm, stopping the traffic all the evening.

On Sunday, 17th July, we were troubled from 11:35 a.m. to 1:30 p.m. (Greenwich time) on most of our circuits, after this all was tranquil again. I noticed that the cables most affected during these storms were invariably those running east and west.—Yours, &c.,

Syra, Greece, 1st Sept., 1892. W. H. COTTRELL.

[A number of reports from cable stations of the storm of July 16 appeared in *The Electrician* of Aug. 5, 1892, p. 358.—ED. *E.*]



Earth potentials observed at the Syra Station on the Syra-Zante Cable (*via* Corinth) during the electric storm of July 16, 1892, at 7:50 p.m. Greenwich time. Direction of Cable, E. and W. Resistance of Circuit, 2,790 ohms. Readings observed every five seconds.

Maximum positive potential	111 volts
,, negative ,, ...	76 ,,
,, positive current	40 milliamperes
,, negative ,, ...	27 ,,
Total difference of potential	187 volts

ELECTRICITY IN THE ROYAL NAVY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the very interesting Paper on this subject by Mr. H. E. Deadman that you publish in your issue for the 16th inst., perhaps I may be allowed to point out that it is not, I think, correct to attribute the credit of the introduction of electricity for the temporary lighting of ships under construction to Portsmouth dockyard. I think I am right in believing that this arrangement was first adopted at the Elswick ship-yard of Messrs. Sir W. G. Armstrong and Co. by Mr. W. H. White, who is now Director of Naval Construction in the Admiralty, but who at the time was director of Messrs. Armstrong's yard. It may also be mentioned that the introduction of lead-coated wires for ship wiring, which, in Mr. Deadman's opinion, constituted an important improvement, was also due to the Elswick firm, having been first employed in the electric lighting of the Japanese cruiser "Naniwa-Kan," which was fitted at Elswick under my superintendence. Mr. Deadman does not mention the name of the firm that has been successful, alone amongst English makers, in satisfying the Admiralty requirements in the manufacture of search-light mirrors. Messrs. C. A. Parsons and Co., of Newcastle-on-Tyne, are the firm in question.

I think that the above remarks may prove a useful supplement to Mr. Deadman's paper, which is specially valuable as showing the important influence that the English Admiralty has had in the development of electric lighting on board ship.—Yours, &c., A. A. C. SWINTON.

66, Victoria-street, London, September 19, 1892.

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TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Postmaster-General invites tenders for the supply of red fir telegraph poles and for creosoting the same. Forms of tender may be obtained of Mr. Charles E. Stuart, Controller of Stores, Telegraph-street, E.C., and tenders will be received up to noon on Friday, October 21st. Further particulars appear in our advertisement columns.

——— Our advertisement columns contain particulars of the requirements of the Lancashire and Yorkshire Railway for stores, &c. Included in the stores required are copper, copper rivets and washers, india rubber, copper boiler tubes, timber, castings, iron and steel sheets, &c. All further particulars, with forms of tender, may be obtained at the Stores Department of the Company, Osborne-street, Manchester, where samples can also be examined before tendering. The Company desire that intending tenderers shall examine these samples. Tenders addressed to the Directors must be in by 10 o'clock a.m., on Monday, the 3rd October, and tenderers are requested to state the particular contracts for which they desire to tender, as separate forms of tender are provided for each contract.

——— It will be seen from our advertisement columns that the Glasgow Corporation Tramways Committee invite parties desirous of submitting estimates to equip certain of their tramway routes for working on the overhead system to communicate with Mr. John Young, City Chambers, Glasgow.

——— The Corporation of Burnley invite tenders for the supply and erection of machinery and plant for their central station, and for underground cables. The plant required consists of steam boilers and engines, fuel economisers, travelling cranes, dynamos, accumulators, switchboards and cables. Specifications, forms of tender and all other particulars may be obtained from Jno. P. Leather, Gas Works, Burnley, and tenders are to be in by October 26th. For particulars see our advertisement columns.

——— The Great Western Railway Company are inviting tenders for stores, including chemicals, lamp glasses, globes, tubes, &c., india-rubber goods, telegraphic apparatus and iron work, copper, iron, and steel wire, metals, rivets, bolts, nails, screws, telegraph poles and yellow pine, &c., &c. Tenders have to be in by October 3rd.

——— The London, Tilbury and Southend Railway Company invite tenders for various stores including iron castings, nails and screws, English and foreign timber, patent metals, forgings, copper, brass, bronze, and gun-metal, india-rubber goods, packing, cotton waste, &c. Tenders have to be in by noon of the 28th inst.

PLANT FOR SALE.—An advertisement elsewhere gives particulars of a small complete electric light plant for sale.

TENDERS RECEIVED.—The Electric Lighting Committee of Whitehaven have recommended the Town Council to accept the following tenders in connection with the electric light scheme:—Messrs. Ramsay Brothers, Whitehaven, for iron and steel work for foundations of engines and dynamos; Galloways (Limited), for two boilers; Messrs. Willans and Robinson, for four sets of Willans engines and Crompton dynamos; and the International Okonite Company (Limited), for conductors.

TENDERS ACCEPTED.—The following tenders have been accepted by the Vestry of St. Pancras in connection with the extension of arc lighting:—

	£	s.	d.
Contract No. 1:—			
Messrs. J. Smith and Co., for supplying 50 small columns (each)	9	10	0
Messrs. Johnson and Phillips, for supplying 5 large columns (each)	13	10	0
Contract No. 3:—			
Messrs. W. T. Henley's Telegraph Works Company (Limited), for supplying insulated cables, &c.	516	1	3
Contract No. 4:—			
Messrs. C. E. Firmstone and Bros., for supplying cast iron pipes, &c.	193	11	8
Contract No. 5:—			
Messrs. Reid Bros., for laying pipes, &c., constructing manholes, erecting lamposts, &c.	1,171	13	4

No tender for lamps has yet been accepted.

FAWCUS AND COWAN'S PORCELAIN CABLE SUSPENDERS.—Messrs. Fawcus and Cowan have appointed Messrs. Bullers (Limited) sole licensees to manufacture and sell their patent porcelain cable suspender.

PRINTS OF OLD TELEGRAPH SHIPS.—If any of our readers are possessed of litho prints of any of the old telegraph ships, especially those which were engaged in laying the early Atlantic cables, they are invited to communicate with "Telegraphs," care of *Electrician* Office.

COX, ROBINSON, AND CO.—The following figure as creditors for amounts of £20 and over under this failure:—

	£	s.	d.
James Bell, Liverpool	30	0	0
Edison & Swan United Electric Light Co.(Ltd.)Londn.	179	7	0
Electric Construction Corporation (Ltd.), London	29	17	5
Walter T. Glover and Co., Salford	43	17	3
Higson, Southport	31	10	0
Kendrew, Southport	34	10	0
J. McIntyre, Burslem	94	0	0
Nixon, Liverpool	33	5	0
Sadler, J., Liverpool	100	0	0
Sanogen Ventilating Co., Liverpool	26	10	1
Selig, Sonnenthal, and Co., London	16	3	6
Thomas, Birkenhead	30	15	0
Thompson, Liverpool	34	0	0
J. Townend, Manchester	145	0	0
Watts, Liverpool	34	0	0
Woodhouse & Rawson United (Ltd.), London	85	4	0

The total liabilities are estimated at £1,627. 19s. 2d., and the assets (after preference claims) estimated to realise £873. 17s. 2d.

J. E. H. GORDON AND CO.—A contract has been entered into between this firm and the Windsor and Eton Electric Company for the erection of an electric light station, &c., at Windsor, to be ready about Christmas.

DISSOLUTION OF PARTNERSHIP.—The partnership hitherto existing between Messrs. Mottershall and Clarke, 41, Corporation-street, Manchester, electrical engineers and agents, has been dissolved.

THE UNPLEASANTNESS AT PONDER'S END.—We are glad to say that the misunderstanding at the Edison and Swan Company's Works has been arranged to the satisfaction of all parties.

REMOVAL NOTICES.—The offices of the New Telephone Company have been removed from 110, Cannon-street, to "The Telephone Exchange," 58 and 59, London-wall, E.C.

——— The head offices of the Westminster Electric Supply Corporation (Limited) have been removed to the central station at Eccleston-place, Belgravia, S.W.

——— The offices of the Electrical Coal-Cutting Contract Corporation (Limited) have been removed to 17, Victoria-street, London, S.W.

——— Messrs. William Bryden and Son announce that they have removed from 112 to 300, St. Vincent-street, Glasgow.

TEMPORARY LIGHTING.—A successful temporary installation was carried out by Messrs. Rawlings Brothers, of Gloucester-road, S.W., last Thursday, on the occasion of a garden party given by Mr. Burdett-Coutts, M.P., at Holly Lodge, Highgate. The incandescent lamps were run off Epstein accumulators.

AWARD.—Messrs. W. Wilson and Co., electrical engineers, have been awarded a silver medal for their exhibit at the Middleton Agricultural Society's annual show.

BELL'S ASBESTOS COMPANY.—This Company have recently issued illustrated price lists and particulars of their asbestos-packed water gauges, boiler and cylinder, gas, main, and angle cocks, blow-off and fire cocks, and of their asbestos-faced valves. Copies of the new price lists can be obtained on application to the Company.

ELECTRO-HARMONIC SOCIETY.—The opening concert of the forthcoming season will be held at the St. James's Hall Restaurant, on Friday next, the 30th inst., at eight o'clock.

ALLEGED FORGERY.—William Bunday was charged on Wednesday last at the Mansion House, London, with forging the names of Messrs. Heale and Douglas, Directors of Messrs. R. C. Cutting, Douglas and Co. (Limited), electrical engineers, of Wardrobe-chambers, London, E.C. It was stated that the prisoner, as secretary to the Company, had forged the names to cheques for £6 and £2. 8s. 9d., and had obtained payment at the City Bank. He was committed for trial.

ABERYSTWITH.—There is to be a temporary lighting of the Marine-terrace, Aberystwith, by electricity, with a view to its being ultimately permanently adopted.

BELFAST.—At a special meeting of the Corporation held on Wednesday last the question of electricity v. gas for lighting the city was under consideration, and a special committee was appointed to present a report on an early day. The London Central Stations are shortly to be visited by local representatives.

BILSTON.—It has been decided to advertise for tenders for the storage plant for use in the market lighting.

BOLTON.—It is proposed to extend the electric light installation at Bolton, and tenders have recently been submitted to the Gas Committee with this object. It is ultimately intended, we understand, to extend the installation throughout the borough.

BRIDGEND.—The Local Board have decided to appoint a sub-committee to inspect the electric lighting of Lynmouth, with the view to the adoption of the electric light for Bridgend.

BUXTON.—On Friday last, at a meeting of the Buxton Local Board, Mr. Willoughby, the secretary of the Buxton Gardens

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Company, suggested that the electric light should be installed in the gardens. He said that at the Gasworks there was steam and water-power, and he suggested that a central station should be erected there. It is agreed that the necessary information should be obtained and be laid before the Board at the next meeting, it being understood that the Board will itself take the matter in hand.

DOLGELLY.—In reference to the paragraph which appeared in our issue of the 9th September water power will be used in this installation, which is to be completed by the end of the present month. The contract consists of about 60 lamps, and is undertaken at the same price as that paid to the Gas Company at present.

DUNDALK.—We understand arrangements have been made for renewing the Provisional Lighting Order obtained by the Town Commissioners in 1885, the Commissioners having still under consideration the question of introducing the electric light.

FIUME (AUSTRIA) —The Town Council of Fiume invites tenders up to October 1st for the building and working of a tramway in their town. Contractors are at liberty to use electricity as the motive power.

FLEETWOOD.—The Fleetwood Improvement Commissioners at their last meeting decided not to entertain the offer of the Fleetwood Gas Company for the purchase of their works, a desire being expressed that a comprehensive scheme for lighting the town by electricity should be introduced. Estimates have, we understand, been already received by the Commissioners, and in addition four other firms are preparing tenders, the firms who have previously tendered being allowed an opportunity to revise their offers.

GLASGOW.—The Corporation's electric lighting installations at Glasgow is progressing rapidly, and a large number of private firms in the central districts of the city have decided to adopt the electric light, and are having the necessary wiring and fittings put in.——A series of articles is appearing in the *Glasgow Herald* dealing with the question of Cables *v.* Electricity for tramways.

HASTINGS.—The Hastings Town Council have decided that in future the electric light is to be the sole illuminant of the Hastings and St. Leonards parades. They have accepted the offer of the Hastings Electric Light Company to provide 52 arc lamps, 80 yards apart, for three years at £25 per lamp per annum. A saving of £68 per annum is estimated to result as compared with the cost of the present system of lighting by gas and electricity.

HORNSEY.—At the last meeting of the Hornsey Local Board the question of supplying the electric light to the district of Crouch End was referred to the Lighting Committee.

JAMAICA.—The Kingstown (Jamaica) papers to hand contain particulars of a meeting of the City Council at which they discussed the report of a select committee appointed to deal with the question of the lighting of the city with electricity. The Committee have decided to ask the local Electric Light Company for a plan showing the suggested lighting arrangements. The Company offer to supply, for one year, 50 arc lamps at a cost of £30 per lamp per annum, such lamps to have a candle-power of 60,000 as against the 4,200 candles of the present gas lighting, which costs £1,950 as against the £1,500 estimate of the Electric Lighting Company. As at present constituted the gas works, which practically belong to the local authority, are carried on at a loss. The proposal to introduce the electric light finds considerable favour with the local press.

LEICESTER.—Tenders have been received for laying the necessary mains for lighting the town of Leicester, and in all probability the Council will be recommended by the Gas Committee to carry out the terms of the lighting order, which has been in abeyance for some time.

PLYMOUTH.—The Lighting Committee of the Plymouth County Council have had under consideration the desirability of lighting the town with electricity. The matter will be again discussed later.

ROMNEY MARSH.—The new Romney Corporation have under consideration the introduction of the electric light into the borough.

SCARBOROUGH.—The Electric Lighting Sub-Committee, at their meeting on the 16th inst., reported that they had instructed Mr. Bernard Drake to prepare a report as to the terms on which he would advise the Corporation to transfer their powers under the Provisional Order to a Company. The Sub-Committee's report was adopted.

TAUNTON.—The *Somers t Express* of September 17th contains the correspondence which has recently taken place between the Town Clerk and the Laing, Wharton, and Down Construction Syndicate (Limited), in reference to the appointment of an expert to report upon the electric lighting installation in the town. At the meeting of the Council on the 13th instant the Mayor stated that any opposition to the electric light would be received with regret, the only question being whether it would pay the Corporation to take over the electric lighting works; he had looked over the file of a local paper of 16 years ago with reference to the purchase of the water works, and found that in that case it was prophesied that the Corporation would suffer a considerable loss, instead of which a very large profit had resulted. In the result the report of the Committee recommending that the Council should purchase the electric lighting works was adopted, in spite of some unusual opposition.

COMPANIES' MEETINGS & REPORTS.

The Direct Spanish Telegraph Company (Limited).

The thirty-eighth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., on Tuesday last, under the presidency of Sir James Anderson.

The MANAGER (Mr. Charles Gerhardi) read the notice convening the meeting and the minutes of the last meeting, which were confirmed by the present meeting and signed by the chairman. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I may preface my few remarks by saying that I have scarcely anything to tell you. You may remember that at our last meeting in March I called attention to the reduction of our tariff by ½d. per word, and said that if the traffic did not increase our loss would be £1,700 odd. But I was also in a position to say that the growth of the Spanish traffic which had resulted from the Commercial Treaty with Spain in 1886 had continued, that we had carried 7,900 more telegrams, or 43,000 more words, than in the corresponding period of the previous year, and that in each year from 1886 there had been a continuous growth, so that we did not take a despairing view of the loss of that ½d. per word which the Conference had inflicted upon us. Now this half-year there has been an increase of 10.000 telegrams compared with 7,900 in the corresponding period last year, or 130,000 words as compared with 43,000 last year. I am obliged to say, however, that this is not all the result of normal growth, as the merchants using our lines, with the object of getting their goods into Spain before the treaty expired in June last, employed our cables very freely. Still, one thing with another seems to force merchants into the use of the telegraph, and once they become accustomed to carrying on their business by telegraphy, they do not easily fall back upon the old method of letter writing. I hope this is as I put it, because it is the mainstay of our revenue. There is never much good in abnormal events, which stimulate telegraphy for a time, with the result of shrinkage, depreciated currency, and a good deal of bankruptcy after the undue inflation consequent, say, upon war or the formation of all sorts of companies. Telegraphy, in my opinion, does best when the business pendulum swings both ways with a profitable result. Of course I do not know whether we are now in this safe position, but it is enough to know that since the treaty expired on June 30th, the growth of our traffic is still on the increase. The reduction in the length of the messages by codifying has ceased, and we are now one word per message better than we were a few years ago, when there seemed no end to the ingenuity of code makers. Without attempting to prophesy or forecast the result of the future I think we must let it take care of itself. Three minutes to Bilbao and twenty minutes to Madrid for a telegraph message comes as near dealing with your foreign correspondent in the same room as can be desired. I pass over paragraph 3 of the report, referring to a slight increase in working expenses, as hardly calling for any special remark; and paragraph 4 is a comfortable record of no expenditure upon repairs. Paragraph 5, however, may remind you that I said at our last meeting that your Directors looked forward to replacing the £2,376 which we had taken from our reserve for the repair of our Bilbao cable out of future profits, and that our opinion was we should not pay more than 4 per cent., or even less, if need be, until this was accomplished. You know we had what we called a contingency fund which also had to be expended. Now we are looking forward to the renewal of our Six per Cent. Debentures at a lower rate in 1894, but that will greatly depend upon our re-instating our reserve out of profit, and even providing another contingency fund. I cannot say I see the latter, the contingency fund, but I do not take a gloomy view of our prospects. Much depends upon freedom from breaks and expensive repairs. Still, I make this statement as showing you the policy your Directors desire to pursue—a policy which, if carried out, will maintain your shares as a good investment with as little fluctuation as one sees among the better securities in the list of the London Stock Exchange. That is all I can find to tell you, and I thought really that I should have nothing to say to you. We are making a very fair revenue, and we must be satisfied with it. I have no idea what may happen at the next Conference, which I am happy to say is three years off, and ideas which the Post Office and the European Powers may be entertaining, may be modified after that. At present they are talking—and I hope it is only talk—of a uniform European tariff: but I think from the way things are going on that a good many governments are losing by their telegraphs. The Australian colonies want to put up the tariff, and I hardly expect that there will be any great desire to lower the tariffs. It will not pay to do so. You cannot lower the tariff without making a loss, and 4 per cent. is not too much—it is really not enough—to pay in this class of enterprise. With these remarks I move—

"*That the report and accounts now presented be and are hereby received and adopted.*"

Mr. EDMUND ETLINGER seconded the motion.

The CHAIRMAN: If any gentleman has any remarks to make I will do what I can to reply to them. If not, I will ask your approval of the motion.

The resolution was carried unanimously.

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The CHAIRMAN: The next resolution is--

"*That the dividend at the rate of 10 per cent. per annum, less income tax, on the preference shares, and a dividend at the rate of 4 per cent. per annum on the ordinary shares, free of income tax, both for the half-year ended June 30, 1892, be and are hereby declared.*"

Mr. ETLINGER seconded the resolution, which was unanimously agreed to.

Mr. COCHRAN said he was sure he was only acting in accordance with the feelings of the shareholders generally when he proposed a vote of thanks to the Chairman for his able conduct in the chair, and to the other Directors also, for their management of the business in the past half-year. The shareholders felt that the position was not quite so bright as they would like to see it; but, taking everything into consideration, he thought they had reason to be satisfied.

The motion was seconded, and unanimously approved.

The CHAIRMAN: On behalf of my colleagues and myself I am extremely obliged to you for the confidence you have expressed in us. It is all very well to wish for good times, but if they will not come what can we do? In face of the fact that we must have our debentures replaced in 1894, I think we must make ourselves as strong as we can. I am sorry that I have not had anything more cheering to tell you. I thank you again, on the part of my colleagues and myself, for your confidence in us.

The meeting then separated.

NEW COMPANIES, STATUTORY RETURNS, &c.

ELECTRO ALKALI (LIMITED).—This Company was registered on the 20th September with a capital of £160,000, in £10 shares. The objects are:—To enter into and carry into effect with or without modification an agreement to be made between the Electric Construction Corporation (Limited) of the one part and this Company of the other part, providing for the acquisition by this Company of the patents and patent rights and licences in the said agreement, to purchase or otherwise acquire any other inventions, patents, patent rights, &c., relating to any chemical, electrolytical, electro-chemical, or other processes or to any apparatus, implements, or machinery for or in connection with electricity and generally to develop, improve, bring into public notice and use the said or other inventions. The subscribers are— Shares.

W. Young, 109, Grofton-road Peckham-road, S.E.	1
F. J. Allen, 14, Trelawn-road, Brixton, S.W.	1
F. Virgo, 93, Earl's Court-road, S.W.	1
W. H. McCarthy, 101, Brook-street, Kennington, S.E.	1
J. Payne, 5, Richmond-terrace, Clapham-road, S.W.	1
J. R. Threadfold, 19, Shenley-road, Camberwell	1
S. T. Bishop, 6A, York-grove, Peckham, S.E.	1

The number of Directors is not to be less than three nor more than seven (including Managing Director), the first to be appointed by the above-named signatories. Qualification for Directorship to be £100, remuneration £100 per annum each, and 10 per cent. on gross profits, and also 10 per cent. on the amount realised by certain sales of patents, the said remuneration to be divided as they themselves determine.

LONDON HEALTH ELECTRICAL INSTITUTE (LIMITED).—A company has been registered under the above title, with a capital of £10,000 in £1 shares, to adopt and carry into effect an agreement between G. J. Spalding and M. C. Spalding and T. J. Henderson, to acquire, develop, and carry on the businesses carried on under the following titles:—"*The Magneto-Electric Battery Company*," and "*The London Health Electrical Institute*," or "*The Health Electrical Institution of London*," to provide for the treatment of diseases by electricity, and to carry on the business of manufacturers of and dealers in electrical appliances.

NEW ELECTRICITY SUPPLY COMPANY OF CROYDON (LIMITED).—This Company has been registered with a capital of £40,000, divided into 7,900 ordinary shares of £5 each, and 100 Founders' Shares of £5 each. The objects are:—To tender for the transfer to the Company, and subsequently to become transferees of all or any of the powers and obligations conferred by or appertaining to the undertakers under the Croydon Corporation Electric Lighting Order, 1891; to obtain by purchase, lease, or otherwise, land and premises suitable for the erection of a central electricity supply station, and all works connected therewith, to be situate in Croydon, in the county of Surrey, and generally to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, and manufacturers and dealers in all or any of the apparatus and appliances necessary for or connected with the generation, distribution, supply, accumulation, and employment of electricity. The signatories are: Shares.

Richard Binnie, 8, Forest-rd., Forest Gate, E.	1
David Pitcairn, 7, New-sq., Lincoln's Inn, W.C.	1
Martin Taylor, 11, Southbridge-rd., Croydon	1
Edward E. Henderson, 12, Lancaster-place, N.W.	1
William F. Taylor, Boswell-ct., Croydon, Electrical Engineer	1
John W. B. Unwin, 58, Southbridge-road, Croydon	1
Charles E. Harrison, 263, Strand, W.C.	1

The number of directors is not to be less than three nor more than seven exclusive of managing director. In connection with the above, a company was registered on June 28, 1889, with a capital of £5,000 in £5 shares, under the name of "The Croydon Electric Supply Company (Limited)." Only seven shares have been taken up in this latter concern.

OZONE SYNDICATE (LIMITED).—This Company was registered on September 15th with a capital of £25,000, in £5 shares, by Mr. Sydney Morse, 4, Fenchurch-avenue, E.C. The objects are to carry on within the United Kingdom the business of ozone producers, sugar refiners, engineers and contractors, manufacturers of sugar refining machinery, and other apparatus; electrical, mechanical, and chemical engineers, and any other business which may be considered to be conveniently carried on by the Company; and to acquire lands, works, property, premises wherever convenient, patents, patent rights, &c. The signatories are:— Shares.

John Raworth, 49, Queen Victoria street, E.C. (Chief Engineer to the Brush Electrical Company)	1
B. Broadhurst, 2, Glenthorn Villas, Surbiton, S.W.	1
W. C. Manns, 19, Upper Kyverdale-road, N.	1
R. A. Dawburn, Wandsworth, S.W.	1
G. B. Mee, 93, Leadenhall-street, E.C.	1
W. W. Gold, 23, Leadenhall-street, E.C.	1
J. Hepper, 34, Burney-street, Greenwich, S.E.	1

Registered office, 39, Victoria-street, S.W.

MISCELLANEOUS.—PATENT AUTOMATIC COUPLER SYNDICATE (LIMITED): Capital £10,000, in £1 shares. To acquire, develop, work, and turn to account Patent No. 2,129 of 1887.——CAMBRIAN ESTATES (LIMITED): Capital £50,000, in £1 shares. Includes the supply of electric light on the estates to be acquired by the Company.——AUTHORISED DISINFECTOR COMPANY (LIMITED): Capital £3,000, in £1 shares. Sanitary, mechanical and electrical engineers, sanitary inspectors, builders, &c.

PIONEER TELEPHONE COMPANY (LIMITED).—A copy of the resolution for the winding up of the above-named Company has been duly filed at Somerset House.

TELEPHONE COMPANY OF AUSTRIA (LIMITED).—The ninth annual return of this Company, made up to August 16th, has been filed. The Company was registered on April 27, 1883, with a capital of £100,000, in £5 shares, to acquire from the Consolidated Telephone Construction and Maintenance Company (Limited) and the Edison-Gower-Bell Telephone Company of Europe (Limited) certain concessions for the establishment and working of telephonic communication in the towns of Prague, Graz, Trieste, Lemberg, Reichenberg, Pilsen, Czernowitz, Bielitz-Biala, and Cracow, granted by the Government of the Austrian Empire, and to carry on in the Austrian Empire the business of a telephone company and an Electric Light, Heat, and Power Supply Company in all or any of their respective branches. In consideration for these concessions, 6,000 shares were allotted as fully paid to Sir Julius Vogel, Colonel George E. Gouraud, and Sir Alexander Armstrong; and in consideration for other interests, 2,000 shares were issued as fully paid to the Consolidated Telephone Construction and Maintenance Company (Limited). By special resolution, passed June 17, 1886, the capital was increased to £200,000 by the creation of 20,000 Preference shares of £5 each. At the time of making up, 11,703 Ordinary and 7,358 Preference shares had been taken up, of which a total of 11,553 Ordinary shares had been issued as fully paid. Upon the remaining 150 Ordinary and the 7,358 the full amount had been called, and all calls (£37,540) had been paid.

CITY NOTES, &c.

BABCOCK AND WILLCOX (LIMITED).—The first ordinary general meeting of this Company was held on Tuesday last. Mr. Andrew Stewart, who presided, stated that those shareholders who held shares during the half-year ended December received an interim dividend of 10 per cent. on ordinary, and six per cent. on preference shares, which absorbed £8,471 of the half-year's profits. The dividend now paid was 15 per cent. on the ordinary and six per cent. on the preference shares which would absorb £13,500. Adding that amount to the interim dividend, the total amount paid in dividends for the year will be £21,971. Other profits had been made, but were put aside, in the form of £19,079 in the reduction of values of various accounts and £9,459 to be carried forward to the credit of next year. With such a favourable balance-sheet, some of the shareholders might think they ought to pay a larger dividend and to carry a smaller sum to next year, and reduce by a smaller amount the various accounts enumerated. These points were carefully cousidered by the board, who had decided to act on the same safe and sound lines which distinguished it as a private company. The plant and machinery had been kept up in excellent condition, and modernised and improved where needed, in order that they might hold that front position which we now occupy in the manufacture of water tube boilers. The Directors' report and accounts were adopted unanimously.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 18th were £744, as against £684 for the corresponding period of last year, being an increase of £60. The total receipts for half-year amount to £9,203, against £8,418 in the corresponding period of 1891, being an increase of £785.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment on the 14th October next of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares of the Company for the quarter ended September 30th; and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income-tax, in respect of profits for the quarter ended June 30th. The register of transfers will be closed from the 7th to 14th October, both days inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend for the quarter ended 30th June last of 2s. 6d. per share,

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free of income tax, payable on 15th Oct. prox. The share register will be closed from the 7th to 14th Oct., both days inclusive.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—This Company have declared an interim dividend of 1s. 9d. per share payable October 18.

PHONOPORE COMPANY (LIMITED).—Mr. Henry Grierson, a Director of the North British Railway Company, Mr. Henry Seebohm, Mr. Forster Webster, and Mr. Arthur Rust have joined the Board of this Company. The Right Hon. Sir Mountstuart E. Grant-Duff has been elected Chairman, and Mr. C. E. P. Spagnoletti, M.I.C.E., Managing Director.

ROCKHAMPTON (QUEENSLAND) GAS AND COKE COMPANY.—Messrs. William Coward and Co., of Queen Victoria-street, E.C., notify that they are prepared to pay the dividend on the shares of the above Company due to English shareholders for the six months ended June 30 last, at the rate of 10 per cent. per annum. This Company is also an electric lighting company, and reference is made to the Directors' report in our issue of September 9.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated receipts of this Company for the fortnight ended Sept. 15, 1892, were £2,146, compared with £1,844 for 1891, showing an increase of £302.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 16, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,584.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 14.		Price Wednesday, Sept. 21.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 21. Highest.	Lowest.
			TELEGRAPHS					£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	48	49	48	49	5 7 0	Jan., Apr., July, Oct.	..	..
£2,876,140	Stock	25/0	Do. Preferred	89	90	89	90	6 3 7	" "	89½	89½
£2,876,140	Stock	5/0	Do. Deferred	10¼	10⅞	9⅞	10¼	..	" "	10¼	1
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¼	11⅜	11¼	11⅜	5 19 2	Mar., June, Oct., Dec.	11⅜	11⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	$1⅔	Commercial Cable Capital Stock xd	160	165	155	165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11	12	11	12	6 13 4	February and August	11⅞	11⅞
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	18	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3⅝	3½	3⅝	4 16 9	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅛	11⅜	11⅛	11⅜	5 18 2	" "	11⅞	11⅛
400,000	10	5/6	Eastern	14⅝	15⅛	14⅞	15⅛	4 6 8	Jan., Apr., July, Oct.	15⅛	14⅝
70,000	10	6%	Do. 6 per Cent. Prefereuce	15½	16	15½	16	3 15 0	" "	16	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	110	113	110	113	3 10 10	" "	112	..
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106	109	106	109	4 11 9	May and November	..	..
250,000	10	2/6	Eastern Extension	15	15¼	15	15¼	4 12 7	February & August	..	..
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	109	112	3 11 5	Jan., Apr., July, Oct.	15½	15⅞
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	February & August	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	103	106	103	106	4 14 4	January and July	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103	106	103	106	3 15 16	" "	105½	..
180,227	10	3.9	Globe Telegraph and Trust	10½	10⅝	10½	10⅝	4 12 4	February & August	..	..
180,042	10	6%	Do. 6 per Cent. Preference	15⅜	15⅝	15⅜	15⅞	3 16 10	Jan., Apr., July, Oct.	10⅝	10½
150,000	10	5/0	Great Northern	18½	19	18½	19	4 9 6	" "	15⅞	15½
£220,000	100	5%	Do. 5 per Cent. Debentures, 18 3	105	108	105	108	4 12 7	Jan., April, and July	19	18⅝
17,000	25	37/6	Indo-European	42	44	42	44	5 13 8	March & September	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	5 14 4	May and November	43½	43⅜
£100,000	100	6%	Do. 6 per Cent. Debentures	105	103	105	108	5 11 1	" "	..	..
10,502	8	8/0	Reuter's	7	8	7	8	5 0 0	March & September	..	..
3,381	£100 Cert.	£1⅞	Submarine Cables Trust 6%	116	121	116	121	4 19 2	April and October	7½	..
15,609	10	5/0	West African Telegraph	6½	7½	6½	7½	5 6 8	" "	117½	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	January and July	..	..
30,000	10	2/0	West Coast of America	3	4	3	4	..	March & September	102	100½
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	January and July	..	..
88,321	10	6d.	West India and Panama	1	1½	1	1½	..	June and December	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½	9⅝	9½	9⅝	6 3 1	" "	1⅝	1⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8	9	8	9	6 13 4	May and November	9⅝	9⅛
64,242	15	6/0	Western and Brazilian	9	9½	9	9½	6 6 0	" "	..	..
33,129	7½	1/3	Do 5 per Cent. Cumulative Preferred	6½	6⅝	6½	6⅝	5 11 1	" "	9⅛	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2⅜	3½	2⅜	3½	..	" "	6⅝	6⅞
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	" "	2⅝	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123	128	123	128	5 9 5	" "	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	97	102	97	102	5 17 8	May and November	..	..
									March & September	..	..
			TELEPHONES.								
22,880	14/0	1¼d.	Consolidated Telephone Const. & Maintenance	⅛	⅜	⅛	⅜	6 10 10	May and November	..	..
22,000	£1	4¾d.	Oriental (11s. paid)	1⅞	1⅞	1⅞	1⅞	7 18 2	Yearly	..	..
434,984	5	3/6	National	4⅜	5	4⅜	4⅝	6 3 1	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½	14½	13½	14½	4 4 3	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13½	13⅝	13½	13⅝	4 7 3	" "	13⅜	13⅜
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109	111	110	112	4 0 4	January and July	111⅞	110⅝
48,000	£10	..	New Telephone, Limited (£2 paid)	..	..	1	1½	..	" "	1⅞	1⅝
58,000	5	1/0	United River Plate	1	2	1	2	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	—	—	—
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	10¼	10⅜	10⅜	11¼	..	—	11¼	10⅜
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	—	—
8,332	£5	..	House to House Electric	2½	3½	2½	3½	..	—	—	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5	5½	5	5½	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½	5⅝	5½	5⅝	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16	3 9/16	3 7/16	3 9/16	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16	5 1/16	5 1/16	5 1/16	..	March	—	—
111,000	5	..	London Electric Supply	½	1	½	1	..	—	6⅝	6½
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½	7⅛	6⅝	7	..	—	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4	4½	4	4½	..	—	8 1/16	8⅛
18,680	£5	2,6	St. James' and Pall Mall	7⅜	8⅛	7⅜	8⅛	—	—	8 7/16	..
7,900	£5	7%	Do. 7% Preference	8	8⅜	8	8⅜	..	—	..	..
42,853	5	3%	Westminster Electric Supply (fully paid)	5⅜	6⅛	6	6⅜	2 6 2	—	6⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	3⅛	3⅜	3⅛	3⅜	..	—	3⅛	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	—	2 1/16	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	5⅝	5½	5⅝	6 1 9	January and July	..	..
12,139	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	4½	5	4½	5	..	—	4⅜	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅛	2⅜	2⅜	2⅝	—	—	2⅝	2 5/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	—	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½	22½	21½	22½	5 11 1	February & August	22½	21⅜
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104	106	104	106	4 4 11	March & September	104½	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½	3½	2½	3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6	7	6	7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1/16	¼	1/16	¼	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3½	4	3½	4	9 12 6	May and November	3⅛	3⅜
37,350	12	12/0	Telegraph Construction and Maintenance	43	45	43	45	5 6 8	March and July	..	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103	106	103	106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	..	⅜	⅝	..	—	..	..
—	£5	8%	Do. Preference (fully paid)	..	..	2½	3	..	—	..	..
			RAILWAYS AND TRAMWAYS.								
£2,550	10	7½%	Blackpool Electric Tramway	—	—	—	—	..	..	..	..
10,000	£10	½%	City and South London Railway	2½	3½	2⅜	3½	1 8 6	..	2⅝	2⅜

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NOTES.

Every year now shows a decided diminution in the number of electric lighting Provisional Orders granted by the Board of Trade and confirmed by Parliament. In 1890 no less than 74 Orders were granted, in 1891 the total was reduced to 58, and this year the total is only 24. This progressive decrease was to be expected, and is not altogether unsatisfactory. When an appreciable proportion of the Orders now in the hands of Local Authorities are being worked, and the remainder have been revoked, it will be time enough to "ask for more."

At the present moment there are nearly 200 Orders in force in the United Kingdom, more than half of which have been obtained by Town Councils, Vestries, Local Boards, &c.; and yet, associating the municipalities who have stations actually at work with those who have signed contracts for plant, it will be found that only about one-sixth of the existing municipal Orders have been made use of. This would seem to point to one of two things: either all the remunerative territory has already been occupied, or the majority of Local Authorities regard their Orders merely as a means of stifling private enterprise. In either case a little breathing time would seem advisable—except, perhaps, from the point of view of the company promoter.

A number of investigations of the efficiency and life of glow lamps have recently been published, but in many cases only one or two makes of lamps have been examined, and the tests being carried out under different conditions, they could not readily be compared together. The most important information to a large number of our readers is the efficiency of ordinary modern Edison-Swan lamps, and the only tests of these that have been published appeared in our columns on July 15 last. We have not given much attention to tests of American lamps as it is unlikely that these will be imported into this country, but the article which we have translated from *L'Electricien* and which will be found in another column, contains an account of an investigation of a number of continental lamps, several of which will doubtless be put upon the English market as soon as the present patents expire.

The tables and the curves in M. Haubtmann's article give, together, a very good idea of the important features of the different glow lamps which he has examined. The first column of the tables shows the number of lamps, commencing in each case with ten, which survived after successive intervals of 250 hours. The lamps were tested at two slightly different voltages—a very good idea. It may be observed, for example, that in the first lamp, made by the Compagnie "La Française," no lamps gave way after 250 hours, either at 102 volts or at 110; one gave way at 102 volts after 500 hours, and two at the higher pressure after the same run. At 750 hours, seven lamps remained in each set, and no further extinction took place at 102 volts at the end of 1,000 hours, while at 110 volts one more lamp had failed, leaving six. A very different state of things is to be found in the second table which refers to a Siemens lamp. This was, perhaps, one of the cheap, short-lived, but not necessarily nasty, kind which are "made in Germany." After 250 hours one lamp out of ten gave out at 102 volts, and four had gone at 110 volts. After 500 hours two more failed at the lower pressure, and only four remained at the higher. After 750 hours three survived in each batch, and of these two remained at 102 volts after 1,000 hours, but the whole ten had succumbed to 110 volts. The diminution of candle-power and the falling off of the current, except in the Siemens lamps where there seems to be a rise, is clearly shown. The curves relate not to the behaviour of the batches but to the characteristics of one sample lamp in each case. Though briefly recorded, this is one of the most instructive investigations on the subject that has been published.

If heat were as difficult to measure as light, our knowledge of many branches of science would be very much impeded, since all energy tends to degrade into heat. In the present issue two instances may be found, the measurement of loss of energy by the rate of rise of a thermometer, and a hot-strip ammeter. The measurement of a rate may often be made with great accuracy, although it involves two terms, because a considerable number of observations can generally be made, and from these not only may the rate be determined, but its constancy or gradual change may be readily found. Calorimetry, on the other hand, requires, as a rule, a number of corrections, and it is only in special cases such as the researches of Messrs. Evershed and Vignoles that the method can be safely adopted. In many examples of thermal measurements, equilibrium is maintained, as in the Cardew voltmeter, the Forbes meter, and the Holden recording ammeter, Langley's bolometer, and Gregory and Boy's methods of measuring radiation.

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The bi-metallic thermometer was arranged by Breguet to measure electric currents, but the compound strip coiled in a spiral was a very imperfect arrangement. An attempt to construct not only an ammeter but a meter is to be found in the Geyer-Bristol instrument, of which nothing has been heard since its appearance in 1888. Here there was a compound bar, but the coefficient of expansion of the two parts were sensibly equal, for they were of the same metal, German silver, the difference consisting in the shape, the one being a flat strip, the other a wire, the former remaining cooler than the latter by reason of its larger surface. The feature of the Holden arrangement is the great rigidity of the parts, a property in which the Breguet and Geyer-Bristol systems were very deficient.

The selective screening of ether oscillations of different periods will no doubt some day become a matter of importance. Electromagnetic vibrations of 10 or 20 a second may be sifted out from rapid ones of several millions a second by a wet duster, and the limit range of the human eye and ear allow us to confine our attention to sights and sounds without being distracted by the other vibrations which are continually surging around us. By using an alternating current of so high a frequency that ordinary telegraphic instruments will not respond to them, the phonophore system enables telegraphic messages to pass along a line without affecting the ordinary apparatus on the circuit. By adopting exactly the opposite course, Prof. Elihu Thomson proposes to dispense with local batteries on telephone circuits by maintaining an alternating current on the subscriber's lines. As the frequency does not exceed 32 per second, the sound is inaudible. By means of this system the advantages of a closed circuit are provided, but the connections to earth being made through condensers, the lines are not actually put to earth.

It is no doubt a disadvantage for a central station to have connected to its mains a large number of lamps which will, in all probability, never be used, but which, nevertheless, render it desirable to have plenty of spare plant, and it is with a view apparently of mitigating this evil that the Yorkshire House-to-House Company have drawn up a somewhat complicated system of rebates for the benefit of their Leeds *clientèle*.

As will be seen from our Notes column, it is proposed that each customer shall be called upon to declare the maximum number of lights which he intends to have in use at any one time, and he is then to be allowed rebates upon this basis. Thus, a 10 per cent. reduction will be made for not less than 250 hours' use per quarter of the supply demanded, a 20 per cent. reduction for 500 hours, and so on. If the maximum supply is to be fixed by the total number of lamps installed, then we have no hesitation in saying that only a very few of the Company's customers will benefit even by the 10 per cent. rebate. On the other hand, unless each customer is to make an affidavit that he will never use more than a certain number of lights, it would seem that a recording ammeter will have to be placed in every house. In either case the more usual, if less theoretically correct, method of giving rebates, irrespective of all other considerations, to all consumers whose quarterly bills exceed a certain minimum, would appear less likely to lead to disappointment among consumers.

Dublin.—The Electric Light Works have been taken over by the Corporation.

Obituary.—The death is announced at Dresden on the 14th instant of Dr. Proell, inventor of the well-known cut-off gear.

Personal.—Mr. W. H. Cottrell, divisional manager of the Eastern Telegraph Company's (Syra) station, has been appointed Her Britannic Majesty's Consul for the Islands in the Greek Archipelago, with residence at Syra.

Train Signalling.—The Webb and Thompson electric train staff system has recently been introduced on the Cork and Youghal section of the Great Southern and Western Railway, between Queenstown and Youghal, a distance of over 20 miles.

Accrington.—The Legal and Parliamentary Committee of the Corporation have instructed Mr. Shoolbred to prepare plans and estimates for an installation of the electric light at a cost of £10,000. A site has been purchased for the engine-house and generators.

Communication with Lightships.—The Commission holds its next meetings on the 18th, 19th, and 20th prox., when the report of the recent visit paid to the different lightships will be considered, and evidence will be taken from coastguard officers and masters of lightships.

Whitehaven.—Mr. Rienzi Walton, inspector of the Local Government Board, held his inquiry at Whitehaven as to the proposal of the trustees to borrow £14,000 for the purpose of electric lighting on Tuesday last week. There was no opposition. Dr. John Hopkinson gave evidence in support of his plans.

Toynbee Hall.—The newly-formed electrical society at Toynbee Hall will begin its operations this session. Dr. Fison is announced to give two courses of lectures on electricity, one for advanced pupils at Toynbee Hall, and another for beginners at the Limehouse Town Hall. Full particulars can be obtained by writing to the hon. secs. at Toynbee Hall, Whitechapel, E.

The Electric Light in the House of Lords.—According to *The Times*, concurrently with the redecoration of the House of Lords, gas will give place to electric lighting, for which purpose ten electroliers are being made, each containing 36 16-c.p. lights. This addition to the electric lighting installation will increase the total number of lights in the Palace to upwards of 2,000.

Junior Engineering Society.—The Council of this Society announce that the presidency for the ensuing session has been accepted by Dr. John Hopkinson. The new session will be opened by the delivery of Dr. Hopkinson's presidential address on Friday, November 4th, at the Westminster Palace Hotel. On Friday, October 7th, at 7:30, there will be a general meeting for election of officers and other business at the Westminster Palace Hotel.

The Berlin Electricity Supply Company and its Consumers.—It is reported that there has recently been a meeting of electricity consumers in Berlin. They complained of unsatisfactory meters and the excessive consumption of electricity by the glow lamps. The Supply Company maintains that it is already doing more for its consumers in the matter of fittings, meters, tests, &c., than it is bound to do, but states that it is prepared to lower the tariff at the beginning of next year.

Morley Memorial College.—The fourth session at the Morley Memorial College, Waterloo-road, re-opens on October 3rd, when Sir John Lubbock will distribute the prizes. Besides science and other classes, the College comprises a gymnasium, clubs and social meetings, and last year those who had distinguished themselves in the Science and Art, or the University Extension Examinations, were sent by means of scholarships to Oxford or Cambridge during the University Extension summer meeting.

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Photographic Society of Great Britain.—We had great pleasure in accepting an invitation to visit the exhibition of the Photographic Society of Great Britain last week, and thoroughly enjoyed the beautiful products of this fascinating art, relieved to be free for a little from electrical matters. But having arrived at No. 407, we found no charming bit of landscape in evening light, or Alpine study, but a portrait of a Raworth Patent Pump and a Mordey 20-Pole Alternator! We fled down the neighbouring stairs, but not without a glance at an extraordinary photograph taken with the newly-invented tele-photographic lens.

Spanish Telegraphs.—We extract the following from the *Revista de Télegrafos* of Madrid, September 16, 1892:—"*The Electrician* of London of August 26th gives an account to its readers of the reforms which are being introduced in the Spanish Telegraph service, and of the concessions granted to the *employés* of the same, finishing by saying, 'The Telegraph Corps have thus gained all the points they sought for, *hasta cierto punto, estimada colega, hasta cierto punto* (to a certain point, estimable colleague, to a certain point).'" We can only express the hope that such other grievances as exist may be removed, but we suppose the *personnel* of no service in the world could be got to admit that they had gained all the points they sought for.

The Production of India Rubber in Nicaragua.—The United States Consul at Managua has lately prepared a report on the state of the india-rubber trade in Nicaragua. After describing the various native modes of working the trees, which are all uniformly destructive, he states that the natural supply of india-rubber is yearly decreasing in Nicaragua. The Government attempts no supervision of the forest; anyone may cut the trees, and great destruction is caused by the young trees being tapped as well as the full-grown ones, but it is an incontrovertible fact that, so far, at least, as Nicaragua is concerned, the rubber tree is susceptible of cultivation, and in the district of Managua there are large tracts of land suitable for growing rubber trees. It is the opinion of those persons in Nicaragua, who are interested in rubber production, that the cultivation and improvement of rubber plantations would be very profitable.

The Popp Company.—The following figures, taken from the recently published report of the Compagnie Parisienne de l'Air Comprimé, may be of interest:—The compressed air produced during 1891 was 166,400,000 cubic metres, as against 180,000,000 in 1890. Notwithstanding this, however, the 1891 total receipts exceeded those of the previous year, the total being £78,320. At the end of 1891 the Company had 3,520 customers, who employed 750 motors having a total horse-power of 2,838; the average motor being, therefore, of about 3¾ H.P. The compressed air mains have a total length of 72 miles, and the electric mains 116½ miles. During 1891, 863,750 kilowatt-hours were generated. The Company possesses 785 tons of accumulators distributed among 21 stations. The loss made up to date is about £16,000. Recently M. Victor Popp has resigned his seat as a Director, and has been appointed consulting engineer to the Company.

Penywern House College.—The complete courses of instruction in the engineering department of this college, of which Mr. G. W. de Tunzelmann is principal, are arranged to qualify students for entrance into the Central Institution, Cooper's Hill, and Engineering Works. Of the 22 students who went up for the Central Institution from Penywern House this year 17 passed, and all who have presented themselves for Cooper's Hill since 1889 have passed. The Physical Laboratory contains an extensive collection of standard electrical and magnetic measuring instruments, a fine collection of optical apparatus, including instruments sent by Prof. Rowland, to the Loan Exhibition of Scientific Apparatus held at South Kensington in 1876, and an ample supply of less delicate apparatus suitable for ordinary students. The Chemical Laboratory is fitted up according to the plan drawn up by Prof. H. E. Armstrong, who designed the Chemical Laboratories at the Finsbury Technical College and at the Central Institution.

Effects of Railway Currents on Fire Alarm Circuits.—In reading your Editorial in your issue of July 30th, says Mr. Chas. C. Drake, in the *Electrical World* of August 6th., in reference to electricity, the supposed mischief maker again, I would like to state that since the electric street car road was started, we have had considerable trouble with our police telegraph circuits, which are grounded. When this road was first started, in less than four days a new 10-cell Callaud battery failed on one circuit. After trying to locate the trouble by reversing the ground, I overcame it. In about three weeks the street car company reversed the polarity to ground, unbeknown to me, and in about three-and-a-half or four days my battery failed again. After reversing the grounds and building up the battery again, all went well. But I find that my batteries do not work as well, and will not last more than half as long. I have had to double them; where I only used 48 before, I now use 96, and they are not as satisfactory as before. I reported these facts to our Board of Commons, and recommended that they make our circuit metallic.

The Electromotive Force of Gas Batteries.—In a Paper on "The Electromotive Force of Gas Batteries," Herr G. Markovsky (*Ann. Phys. Chem.*) has given measurements of the electromotive force developed in elements consisting of platinum wholly immersed in dilute, carefully boiled-out sulphuric acid, and of platinum partially immersed in this liquid, and partially exposed to an atmosphere of pure hydrogen and oxygen. His results are given as follows in the *Journal* of the Chemical Society:—The electromotive force of a platinum plate in hydrogen against a platinum plate in gas-free sulphuric acid is 0·646 volt. When oxygen is substituted for hydrogen, the current is in the opposite direction, and the electromotive force is 0·372 volt. Electrolytic hydrogen, and hydrogen prepared from zinc and sulphuric acid, give the same value for the electromotive force. The same thing holds for electrolytic and chemically prepared oxygen. The electromotive force of an oxygen cell is diminished by the addition of platinum sulphate to the solution, whilst that of a hydrogen cell increases, the sum of the two remaining constant. The electromotive force is independent of the density and temperature—up to 70deg.—of the gas. Carbon electrodes behave quite differently rom platinum electrodes.

Leeds.—About December the Yorkshire House-to-House Electricity Company will be prepared to supply current. An arrangement has been come to with the Highways Committee whereby a Corporation staff are at work opening up the streets along which the mains are to be laid. The standard price of eightpence per unit will be subject to discounts based upon the number of hours per quarter during which the current is used, each consumer being called upon to declare the maximum number of lights required to be in use at any one time. The scale of discounts is as follows:—

For not less than	250	hours' use	(per quarter)	of the	supply	demanded,	10	per cent.
„	„	375	„	„	„	„	15	„
„	„	500	„	„	„	„	20	„
„	„	600	„	„	„	„	22½	„
„	„	700	„	„	„	„	25	„

In addition to the discounts accruing under the above table, a discount of 5 per cent. will be allowed on the net amount of accounts paid within one month from the date of rendering, and 2½ per cent. on accounts paid within two months. The effect of the discounts above mentioned is to reduce the price of eightpence per unit to about the following net charges:—

For	250	hours' use	(per quarter),	6⅝d.	per unit.
„	375	„	„	6¼d.	„
„	500	„	„	6d.	„
„	600	„	„	5⅞d.	„
„	700	„	„	5½d.	„

Finsbury Technical College Evening Classes.—We are requested to announce that all available places in the electrical laboratories of the Finsbury Technical College are already filled for Monday and Wednesday evenings; applicants for attendance at the lectures only can be admitted, but there are still some vacancies in the overflow class in the laboratories on Tuesday nights. The evening lectures will be resumed on October 3rd. In the advanced course on Mondays, Prof. Thompson will lecture on Dynamos and Motors; the intro-

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ductory lecture on October 3rd being on Magnetic Fields. The Wednesday night lectures will be on Magnetism, and on Instruments till Christmas. For special lectures at Finsbury there will be first a short course on Accumulators, by Mr. G. H. Robertson, F.C.S., on Thursday evenings, commencing October 6th, and one on Gas and Oil Engines, by Prof. Perry, F.R.S., on Thursdays, commencing October 20th. This will be accompanied by a drawing-class for machine design in Gas and Oil Engines, conducted by Mr. Johnston on Monday evenings. Mr. Clinton gives four lectures on Vector Calculations on Tuesdays, beginning October 22nd. Prof. Perry will also hold throughout the winter a Friday evening course of lessons on the Applications of Higher Mathematics to Engineering Problems. After Christmas Prof. Silvanus Thompson, F.R.S., will lecture on Central Stations, and there will be a course of laboratory lessons in Electrotyping and Electroplating, by Mr. Rousseau.

Electric Lighting Contracts.—If we may judge by some remarks of M. J. P. Anney, in the last number of *L'Industrie Electrique*, the good name of the electrical industry suffers even more in France than in this country from a propensity for undertaking contracts of which the financial success, doubtful at the best, is rendered hopeless by technical blunders of the first order. In support of his statements, M. Anney cites the case of a town in the south of France where the extraordinary fascination which water power has for some people, led to a company coming to grief before it commenced operations. A waterfall capable of furnishing some 200 H.P., but difficult of access, existed about 4½ miles outside the town in question, in which an ultimate load of 20,000 lamps might reasonably be anticipated. Although the waterfall furnished but a small portion of the total power likely to be ultimately required, it was decided to make the generating station there, thus burdening the undertaking from the beginning with a heavy C^2R loss, a long line of conductors, and a high charge for coal cartage. To further complicate matters two systems of distribution were employed; the centre of the town being lit on the continuous current battery sub-station system, and the rest of the town being supplied with alternate currents. The battery charging current, it should be added, had an electromotive force of only 400 volts. To put a finishing touch to the affair, the work was divided up amongst a multitude of contractors, and, in consequence, mishaps abounded. At the present moment the houses wired for the electric light are still awaiting a supply of current.

The Over-regulation of Electric Lighting.—The following remarks prefaced an article on "Some English Measuring Instruments," which was recently contributed to the New York *Electrical Review* by their London correspondent:—The modern Englishman is never happy unless he is under Government inspection. An inspector is always at hand to prevent the simple-minded John from being cheated. Indeed, so well is his safety and well-being looked after that he has only within the last two or three years been allowed to light his house from electric supply mains. When permission was at last reluctantly given, John would have felt somewhat off the track without Governmental aid and advice if he had not had at his elbow the ubiquitous and almighty fire office inspector. This gentleman, at least, knew his own mind (not a very extensive knowledge, perhaps), and, since the prevention of fire was his end and aim, he insisted on three things—you *must* put your wires in casing, inflammable wood casing, if you like, but still casing; you *must* mount your fittings on incombustible materials, no matter if they are hygroscopic or not, and, finally, the insulation *must* amount to so many megohms. The fire office man was not quite clear whether a megohm was a current or a self-induction, but he knew it was good to have plenty of it; the fact that the supply companies insisted on megohms gave him confidence. And so wiring contractors and fire inspectors and other interested parties wandered around hunting for megohms with $200 Wheatstone bridges and galvanometers and a leaky Leclanché cell or two. No two men ever agreed about the number of them when caught, and it generally took longer to test the wiring in a house than it did to put it in.

Forthcoming Electrical Literature.—Amongst a number of scientific books announced as being in the course of preparation, *The Electrician* Printing and Publishing Company (Limited) have in hand the following: "Electromagnetic Theory," by Oliver Heaviside; "A Pocket-Book of Electrical Engineering Formulæ," by W. Geipel and H. Kilgour; "Submarine Cable Laying and Repairing," by H. D. Wilkinson; "Drum Armature Winding, and Commutators," by F. M. Weymouth; and "Electricity as a Motive Power," by Albion T. Snell. Messrs. Macmillan are about to publish "Researches on the Propagation of Electrical Force," by Prof. H. Hertz, translated by Prof. D. E. Jones; "Electrical Papers," by Oliver Heaviside; "Pioneers of Science," by Dr. Oliver Lodge; "The Theory and Practice of Absolute Measurement in Electricity and Magnetism," by Prof. A. Gray, Vol. II. Messrs. Whittaker and Co. have just issued—"Treatise on Lightning Conductors and Lightning Guards," by Dr. Oliver Lodge, and are about to issue "Electrical Experiments," by G. E. Bonney; "A Comprehensive Work on the Dynamo," by C. C. Hawkins and F. Wallis; "Electric Light and Power Distribution," by W. Perren Maycock; "Practical Electric Light Fitting," by F. C. Allsop. "How to Manage a Dynamo," and "Electricity and Magnetism," by S. R. Bottone. Mr. Murray announces "The Collected Works of Werner von Siemens," translated by E. F. Bamber, Vol. II.; "An Introduction to Physical Science," by John Cox. The Clarendon Press have in hand "Mathematical Papers of the late Henry J. S. Smith, Savilian Professor of Geometry in the University of Oxford," and a supplementary volume to Prof. Clerk Maxwell's "Treatise on Electricity and Magnetism," by Prof. J. J. Thomson. Messrs. Baillière, Tindal, and Cox are preparing "A Manual of Practical Medical Electricity," by Dr. Dawson Turner. Messrs. Charles Griffin and Co. announce "Griffin's Electrical Price Book," edited by H. J. Dowsing; Messrs. Longmans and Co., "Lehrbuch der Elektricität," in 2 vols., translated by G. W. de Tunzelmann, B.Sc.; and Messrs. Crosby Lockwood and Sons, "Electric Ship Lighting," by J. W. Urquhart. Messrs. J. and A. Churchill inform us that they hope to issue next year a work on "Lighting," edited by C. A. Groves, F.R.S., and W. Thorp, B.Sc., to which Prof. Garnett is contributing a section on Electric Lighting.

An Apparent Relation of Electromotive Force to Gravity.—In a research on "A General Relation of Electromotive Force to Equivalent Volume and Molecular Velocity of Substances," I have demonstrated, says Dr. Gore, in the September number of the *Philosophical Magazine*, by means of a large number and variety of experimental measurements, that the *dilution* of the liquid of a voltaic cell by means of water or alcohol, the *solution* of either the positive metal or the negative one by means of mercury, the *dilution* of either of these amalgams by means of mercury, or the *dilution* of one solid metal by means of another in an alloy, is universally attended by an increase of mean electromotive force of the diluted and diluting substances beyond the calculated amount, and therefore of the *actual* electromotive force of the diluted one (that of the diluent being very little affected), provided that no chemical union of the diluted and diluting substances occurs. If, however, chemical union does occur, this gain of electromotive force is diminished, or converted into a loss which is larger in proportion as the union is more intimate. In these experiments, by the act of solution or dilution, the molecules of the active or diluted substance are separated farther apart by those of the neutral or diluting one, and acquire greater freedom of motion, whilst those of the diluent approach only slightly nearer together, and do not perceptibly affect the result. It is generally admitted that the particles of all bodies are in an incessant state of motion, that this motion is the *vis viva* or energy contained in the substance, and that the laws of motion apply equally to the smallest as to the largest bodies. If now we regard each molecule of the active substance as vibrating like a pendulum, its movements must obey the law of falling bodies, and the larger the degree of freedom of motion the greater the arc of vibration, the larger the fall, and the greater the velocity of motion. And as in the above-mentioned experiments the volta electromotive force of substances generally has been proved to vary directly as the degree of molecular freedom, it must also, according to this view, be directly related to, and dependent upon, the velocity of molecular motion and the law of gravity in the above manner.

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ELECTROMAGNETIC THEORY.—XXXVII.

BY OLIVER HEAVISIDE.

(*Continued from page 531.*)

§ 165. From the preceding, relating to the magnetic effects produced by moving the medium bodily past stationary electrification; or equivalently, by moving the electrification the other way through the medium; or, more generally, by relative motion of the sources of displacement and the medium supporting it, we may readily deduce the corresponding results when the sources are of the flux induction, instead of displacement. Thus, in (42), (43), do away with the convective electric current $\rho\mathbf{u}$, and substitute convective magnetic current $\sigma\mathbf{u}$, where σ is volume-density of magnetification (suppositional). Our circuital equations are then

$$\text{curl}\,(\mathbf{H}-\mathbf{h})=cp\mathbf{E}, \quad . \quad . \quad . \quad . \quad . \quad (55)$$

$$\text{curl}\,(\mathbf{e}-\mathbf{E})=\mu p\mathbf{H}+\sigma\mathbf{u}, \quad . \quad . \quad . \quad (56)$$

with the auxiliary equations of motional electric and magnetic force

$$\mathbf{e}=\mathrm{V}\mathbf{w}\mathbf{B}, \qquad \mathbf{h}=\mathrm{V}\mathbf{D}\mathbf{w}, \quad . \quad . \quad . \quad . \quad (57)$$

as before, where $\mathbf{w}$ is the velocity of the medium, and with the further auxiliary conditions that the divergence of the displacement is zero, whilst that of the induction is σ. Now we really do not need to employ the formal mathematics. Knowing the results relating to the motion of electrification, we may infer the corresponding ones concerning the motion of magnetification, by making use of the analogies between the electric and magnetic sides of electromagnetism, translating results in the appropriate manner. But as our object is to 'illustrate' the working of vectors as well as electromagnetic principles, it will not be desirable to leave out the mathematics entirely, especially as the safe carrying out of the analogies requires that they should be thoroughly understood first, which requires some practice.

First, if we convert the problem to one of stationary waves, by keeping the sources at rest, and letting only the medium move bodily past them, we have, when the stationary state of induction and displacement is reached, disappearance of the right members of (55) and (56). Then (56) gives, when united with the first of (57),

$$\text{curl}\,\mathbf{E}=\text{curl}\,\mathbf{e}=\text{curl}\,\mathrm{V}\mathbf{w}\mathbf{B}. \quad . \quad . \quad . \quad (58)$$

In the result for a moving point-charge, curl $\mathbf{E}$ is perpendicular to $\mathbf{w}$, so now we may write

$$\mathbf{E}=\mathrm{V}\mathbf{w}\mathbf{B}=\mathrm{V}\mathbf{B}\mathbf{u}, \quad . \quad . \quad . \quad . \quad . \quad (59)$$

where $\mathbf{w}=-\mathbf{u}$, because, similarly, curl $\mathbf{H}$ will be perpendicular to $\mathbf{w}$, and so make $\mathrm{V}\mathbf{B}\mathbf{u}$ circuital. Here $\mathbf{u}$ is the equivalent velocity of the sources, when the medium is stationary. Thus $\mathbf{E}$, and therefore $\mathbf{D}$, are fully known in terms of $\mathbf{B}$. Comparing with (46), we see that the electric force set up when a magnetic charge moves is related to the induction from the charge in the same way as the magnetic force set up when an electric charge moves is related to the displacement from it, with, however, a change of sign, or reversal of direction.

Using the second of (57) in the other circuital equation (55) produces

$$\text{curl}\,(\mathbf{H}-\mathrm{V}\mathbf{u}\mathbf{D})=0=\text{curl}\,\mathbf{f}, \text{ say}, \quad . \quad . \quad (60)$$

where, by (59),

$$\mathbf{f}=\mathbf{H}-c\mathrm{V}\mathbf{u}\mathrm{V}\mathbf{B}\mathbf{u}=\mathbf{H}+\mu c\mathrm{V}\mathbf{u}\mathrm{V}\mathbf{u}\mathbf{H}, \quad . \quad (61)$$

or, if $\mathbf{u}$ is parallel to $\mathbf{k}$,

$$\mathbf{f}=\mathbf{H}+\frac{u^2}{v^2}\mathrm{V}\mathbf{k}\mathrm{V}\mathbf{k}\mathbf{H}=\mathbf{H}+\frac{u^2}{v^2}(\mathbf{k}\mathrm{H}_3-\mathbf{H})$$

$$=(1-u^2/v^2)\mathbf{i}\mathrm{H}_1+(1-u^2/v^2)\mathbf{j}\mathrm{H}_2+\mathbf{k}\mathrm{H}_3; \quad . \quad . \quad (62)$$

from which we see that the vector $\mathbf{F}$ derived from $\mathbf{f}$ by $\mathbf{f}=(1-u^2/v^2)\mathbf{F}$ has no curl, or is derived from a scalar potential Ω thus, $\mathbf{F}=-\mathrm{v}\Omega$, and that the induction is given by

$$\mathrm{B}_1=-\mu\frac{d\Omega}{dx}, \quad \mathrm{B}_2=-\mu\frac{d\Omega}{dy}, \quad \mathrm{B}_3=-\mu(1-u^2/v^2)\frac{d\Omega}{dz}. \quad (63)$$

That is, the induction distributes itself in the same way as if the medium were at rest, but had its inductivity reduced from μ to $\mu(1-u^2/v^2)$ in the line of motion. In fact, the theory of the effects produced by relative motion of magnetic sources and the medium is essentially the same as that of moving electric sources; translating displacement in the latter case to induction in the former, permittivity to inductivity, electric potential (real or fictitious, as the case may be) to magnetic potential, and the magnetic induction which accompanies moving electrification to electric displacement set up by moving magnetification, remembering, however, the change of sign.

We know, therefore, the result of the steady rectilinear motion of any distribution of magnetic sources. If the same motion is common to all the elementary sources, we reduce the problem to that of magnetic eolotropy without relative motion of the medium and sources, and there is a definite system of surfaces of equilibrium ($\Omega=$ constant) where we may, if we please, terminate the electric and magnetic fields, thereby substituting new arrangements of magnetic sources for the old. In this case it is most convenient to keep the sources at rest, and move the medium alone.

But should the relative motion of source and medium not be the same for every source, then, since we cannot move the medium bodily more than one way at a time, we may imagine it to be stationary, and obtain the effect due to the motion of the magnetification by superimposing the separate effects of the elementary sources, which are known by the above.

§ 166. There is, however, no such thing as magnetification, the magnetic analogue of electrification. The induction is always circuital. If it were not circuital, we should have unipolar magnets. We must, therefore, somewhat modify the conditions assumed to prevail in the above, in order to come closer to reality. Consider, therefore, instead of magnetification, a distribution of intrinsic magnetisation. This quantity is $\mathbf{I}=\mu\mathbf{h}_0$, where $\mathbf{h}_0$ is the equivalent intrinsic magnetic force. Abolish σ in (56), and introduce $\mathbf{h}_0$ in (55). The circuital equations are now

$$\text{curl}\,(\mathbf{H}-\mathrm{V}\mathbf{D}\mathbf{w}-\mathbf{h}_0)=cp\mathbf{E}, \quad . \quad . \quad (64)$$

$$\text{curl}\,(\mathrm{V}\mathbf{w}\mathbf{B}-\mathbf{E})=\mu p\mathbf{H}, \quad . \quad . \quad . \quad . \quad (65)$$

where we have introduced the motional forces (57). In the steady state, the right members vanish as before. Now assume that

$$\mathbf{E}=\mathrm{V}\mathbf{w}\mathbf{B}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (66)$$

so that the theory is unchanged so far, the displacement depending on the induction and velocity of the medium in the same way as when the source was magnetification. We shall see the limitation of application later. Next put (66) in (64) and we find, if the fraction $1-u^2/v^2$ be denoted by s,

$$\text{curl}\,\mathbf{f}=\text{curl}\,\mathbf{h}_0, \quad . \quad . \quad . \quad . \quad . \quad (67)$$

$$\text{curl}\,\mathbf{F}=\text{curl}\,\mathbf{h}_0/s, \quad . \quad . \quad . \quad . \quad (68)$$

where $\mathbf{f}$ and $\mathbf{F}$ are the same vectors (in terms of $\mathbf{H}$) as in the last case, such that $s\mathbf{F}=\mathbf{f}$. We see that the vector $\mathbf{F}$ has now definite curl, and that the induction is derived from $\mathbf{F}$ by

$$\mathrm{B}_1=\mu\mathrm{F}_1, \qquad \mathrm{B}_2=\mu\mathrm{F}_2, \qquad \mathrm{B}_3=\mu s\mathrm{F}_3; \quad . \quad (69)$$

that is to say $\mathbf{B}=\lambda\mathbf{F}$, where λ is the inductivity operator whose scalar principals are μ, μ, and μs. We therefore have to find the steady state from these complete connections,

$$\text{div}\,\mathbf{B}=0, \qquad \mathbf{B}=\lambda\mathbf{F}, \qquad \text{curl}\,\mathbf{F}=\text{curl}\,\mathbf{h}_0/s. \quad (70)$$

That is, the induction is the same as in a stationary eolotropic medium (according to λ), provided the intensity of the intrinsic magnetic force be increased from $\mathbf{h}_0$ to $\mathbf{h}_0/s$. This is an important point.

We know that there are certain respects in which the theory of induction due to intrinsic magnetic force is identical with that due to magnetification. For instance, the steady induction outside a magnet due to $\mathbf{h}_0$ is the same as that due to a distribution of σ, measured by the convergence of the intrinsic magnetisation. From this we might hastily conclude that the disturbance from the steady distribution produced by moving the medium would be the same for $\mathbf{h}_0$ as for the equivalent σ, provided we keep outside the region of magnetisation. But the above investigation only partly confirms this conclusion. It

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shows a likeness and a difference. The likeness is in the eolotropic peculiarity brought in by the motion. In both cases we may do away with the motion provided we simultaneously reduce the inductivity parallel to the (abolished) motion from μ to $s\mu$, so as to cause the induction to retreat from this direction and concentrate itself transversely. The difference is in the reckoning of the strength of sources. In the case of magnetification (as of electrification) we do not alter the strength of the source. But in the case of magnetisation we do, or, at any rate, produce an equivalent result. For, along with the reduction of inductivity in the direction of motion, we require to increase the intensity of the intrinsic magnetic force from $\mathbf{h}_0$ to $\mathbf{h}_0/s$. Remember that s is a proper fraction, going from unity to zero as the speed of motion increases from 0 to v, the speed of propagation of disturbances.

To exemplify this, put

$$\mathbf{F} = \mathbf{h}_0/s - \nabla\Omega, \quad . \quad . \quad . \quad . \quad . \quad (71)$$

as we see we may do, by the third of (70). Using this in the second and first of (70) we obtain

$$\text{div}\,\lambda\nabla\Omega = \text{div}\,\lambda\mathbf{h}_0/s, \quad . \quad . \quad . \quad . \quad (72)$$

the equation of the potential Ω. Or, in terms of Cartesians,

$$\mu(\nabla_1^2 + \nabla_2^2 + s\nabla_3^2)\Omega = \mu s^{-1}(\nabla_1 h_{01} + \nabla_2 h_{02} + s\nabla_3 h_{03}) \quad . \quad (73).$$

The equivalent magnetification is the convergence of $\lambda\mathbf{h}_0/s$, not of $\mu\mathbf{h}_0$ the real intensity of magnetisation, nor yet of $\mu\mathbf{h}_0/s$, the same increased in a constant ratio.

There is, therefore, a remarkable difference between the two cases of motion of the medium parallel to and transverse to the lines of real magnetisation. Thus, first let $\mathbf{h}_0$ be parallel to $\mathbf{w}$ or $\mathbf{k}$. Then the s^{-1} outside the brackets in (73) cancels the s inside, so that the right member becomes simply $\mu\nabla_3 h_{03}$, where h_{03} is now the tensor of $\mathbf{h}_0$. That is, the effective magnetification is the convergence of the real magnetisation, just as when the medium is at rest. But if $\mathbf{h}_0$ is perpendicular to $\mathbf{k}$, say parallel to $\mathbf{i}$, the right member of (73) becomes $\mu s^{-1}\nabla_1 h_{01}$, or the effective magnetification is s^{-1} times the convergence of the magnetisation, and is therefore increased.

Suppose, for example, our magnet is a straight filamentary magnet. It has two poles, of strength m and $-m$ say, so that induction to the amount m diverges from one and converges to the other pole, whilst continuity is made between them in the filament itself. Now let the medium move past the filament, the direction of motion being parallel to it. Then the strength of the poles is unchanged, but the induction outside is diverted laterally by the effective reduced inductivity parallel to the filament. This case, then, resembles that of a pair of oppositely signed point-charges, if we keep outside the filament. In the limit, therefore, when the speed is raised to v, we have a pair of parallel plane induction-sheets whose cores are joined by the straight filament of induction, to make continuity.

For (66) to be valid, $\mathbf{B}$ should be such as to make $\mathbf{E}$ circuital. This requires that $\mathbf{w}$ and curl $\mathbf{B}$ should be perpendicular to one another. They are perpendicular in the example just mentioned, on account of the symmetry of $\mathbf{B}$ with respect to the axis or line of motion. But if the same filament be held transversely across the line of motion the property stated is no longer true, so that (66) is not true, and this will, to an unknown extent, upset the later equations. We can, however, still employ them provisionally to obtain a first approximation to the results. On this understanding, then, the strength of the poles (effective) is made m/s and $-m/s$, with unimpaired effective inductivity parallel to the filament, whilst that perpendicular to the filament is reduced, as before. So there is now an increased total induction as well as concentration about the plane through the filament perpendicular to the motion.

We may, however, arrange matters in such a way that the equation (66) shall be still valid when the line of motion is perpendicular to the magnetisation, and so obtain an exact solution showing the increased induction, that is, exact in the absence of working errors. Let the region of magnetisation be confined between two infinite parallel planes, and the magnetisation $\mathbf{I} = \mu\mathbf{h}_0$ be uniformly distributed, parallel to the boundaries. We thus do away with the poles. Now when the medium is at rest the induction is $\mathbf{B} = \mathbf{I}$ within the plate (which may be of any thickness), and zero outside, whilst there is no displacement. The intrinsic magnetic force $\mathbf{h}_0$ produces the greatest effect that it can produce unaided. But if the medium be made to move steadily straight across the magnetised region, then, after certain transient effects have passed away (which may be readily calculated, because they form simply plane electromagnetic waves), although there will still be no induction (or displacement) outside the plate, that within it will be increased (without change of direction) from $\mathbf{I}$ to $\mathbf{I}/s$. That is, the motional magnetic force comes in to assist the intrinsic magnetic force. Here we have the explanation of the previous result relating to the increased effective strength of poles.

Along with this increased induction, there will be electric force, according to (66). It is entirely within the magnetised region. As the speed increases up to v, the induction and the accompanying displacement in the plate go up to infinity.

The theory of an electrised plate is similar. The displacement due to intrinsic electrisation $\mathbf{J} = c\mathbf{e}_0$, where $\mathbf{e}_0$ is the equivalent electric force, the electrisation being uniform and parallel to the sides of the plate, will be increased from $\mathbf{D} = \mathbf{J}$ to $\mathbf{D} = \mathbf{J}/s$ by setting the medium moving straight through it, it being now the motional electric force that assists the intrinsic. The accompanying magnetic force is accordingly given by

$$\mathbf{H} = \mathbf{h} = V\mathbf{D}\mathbf{w}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (74)$$

Outside the plate there is no disturbance in the steady state.

It will of course be understood that if, instead of suppositional impressed or intrinsic forces in a uniform medium, we employ actual material plates, magnetised or electrised as the case may be, they must, in the first place, be non-conductors, and next, they must not interfere with the supposed uniform motion of the medium. In short, the reservation is similar to that mentioned in connection with moving charged conductors. Of course, in our present case, the plates may be moved, whilst the medium is supposed to be at rest.

It will be readily seen that the full investigation of the effects of moving practicable electromagnetic arrangements of conductors presents considerable difficulties. We can, however, get some information relating to the motion of a linear circuit.

(To be continued.)

ON THE PRODUCTION OF THE SPARK OF A HERTZ OSCILLATOR IN A DIELECTRIC LIQUID INSTEAD OF AIR.*

BY MM. SARASIN AND DE LA RIVE.

We have recently made experiments by placing the two little balls of three or four centimetres diameter, between which the discharge of the Ruhmkorff when used as a Hertz oscillator takes place in an insulating liquid, and we have found that by so doing more powerful effects are obtained at the resonator.

The first liquid employed was olive oil. A cylindrical bottle 20 centimetres in diameter was pierced laterally by two holes into which the horizontal rods of the oscillator were inserted through carefully fitted corks; the two little spheres at the end of the rods being thus immersed in the liquid where the spark took place. When the spark gap was progressively increased the tension of the two terminals soon reached its limit, either because it approximated the maximum tension of the inductor, or because the spark went round by the glass bottle instead of traversing the layer of oil. In our experiments we obtained a spark of a little more than one centimetre. The spark occurred regularly, and was accompanied by its characteristic sound, similar to that of a blow, but it was more intense than in air.

The effect of this device on the resonator was most marked. Close to the oscillator the spark became a positive blaze; and at 10 metres distance in the case of resonators of large diameter, 0·75 to 1 metre, it was still very bright and visible from afar. The electromotive force interferences caused by reflection from a plane metallic surface gave the same results

* From the *Comptes Rendus*, Vol. CXV., No. 12, p. 439.

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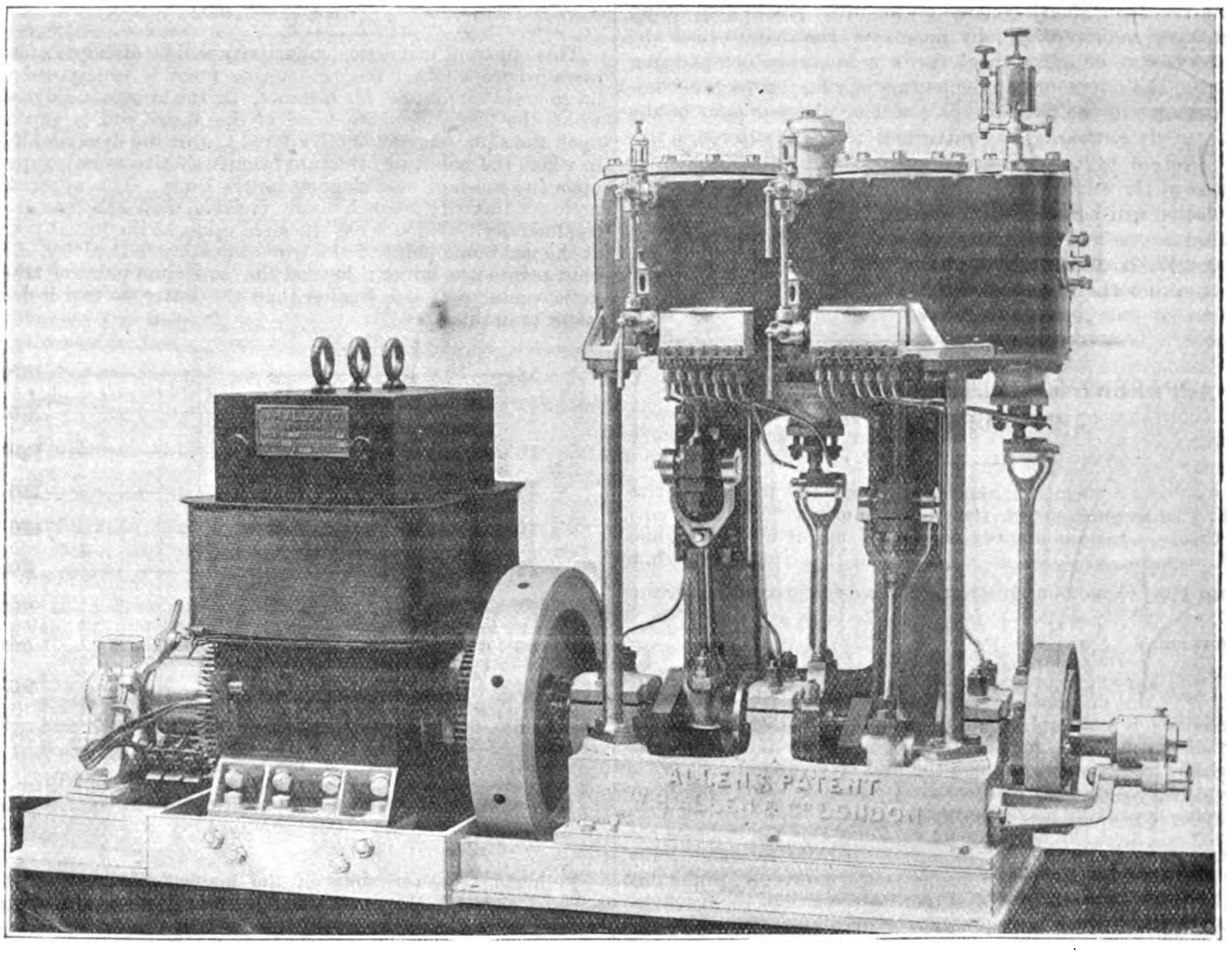
as they do when the discharge of the oscillator takes place in air; that is to say they gave the wave length peculiar to the resonator employed.

Oil carbonises and loses its transparency, but if two litres are employed, as was the case with us, there is no perceptible heating. The impairing of the liquid does not affect the intensity, even when working the apparatus for more than 20 minutes. This fact, when compared with the rapid diminution of effect in air, which has to be remedied by frequent cleaning of the terminals, is a decided advantage. We have also used essence of turpentine and petroleum and obtained analogous results. When using these liquids, however, and especially when using petroleum, a sort of bubbling takes place between the spark and the surface, which might possibly give rise to an explosion. It follows from these first experiments that oil is preferable.

ALLEN DYNAMOS AND ENGINES.

Two engines and dynamos have been recently supplied by Messrs. W. H. Allen and Co. for the Deptford central station of the London Electric Supply Corporation. The larger, when running at a speed of 200 revolutions per minute, has an output of 80 volts 500 amperes, and is driven by a compound engine, having cylinders 9½in. and 16in. diameter by 11in. stroke, the steam pressure being 100lb. The armature of the dynamo is drum-wound, with 104 laminated bars, and has a resistance when warm of 0·005 ohms. The core itself is constructed of charcoal iron discs, 25 mils. thick, insulated with paper, having a diameter of 18in. The field-magnet is shunt-wound, with 34,000 ampere turns. In order to secure an even distribution of the magnetic lines within the air-gap, the polar edges furthest away from the yoke are brought somewhat closer together than the upper polar edges, and by this means any excessive magnetic pull on the armature in an upward direction is neutralised. The current is collected by five 1¾in. gauze brushes off a commutator solidly constructed of hard drawn copper and plates of mica. The smaller machine, which we illustrate, supplies 300 amperes, also at a pressure of 80 volts when running at a speed of 250 revolutions, and is in general of similar make to the larger machine, being driven by an engine having cylinders 8½in. and 14in. in diameter with an 8in. stroke. The armature is 15½in. in diameter and is wound with 132 bars, its resistance when warm being 0·01, while that of the field is 5·5 ohms. By means of two gun-metal angle brackets forming an insulating base to the poles of the magnet the axis of rotation is kept low, whilst the distance between the iron of magnet and the iron of bed-plate is maintained at a normal distance of 6in.



Allen Combined Engine and 24-unit 80-volt Dynamo.

The arrangement of the cylinders of the engines forms the subject of one of Messrs. W. H. Allen and Co.'s patents; by it the steam passes from the high-pressure to the low-pressure cylinder over the top of the central piston valve, which at the same time regulates the compression of the high-pressure cylinder, and the exhaust of the low-pressure; the passage of the steam is thus made as direct as possible through short ports, and great economy is secured in the steam consumption. A central oil-box enables all the working parts to be lubricated from the single reservoir, a detail which is of considerable convenience in cases where continuous running is required.

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The engines are in each case controlled by a flywheel governor, which automatically regulates the amount of steam admitted to the cylinders. When the whole load is thrown off the dynamo the governor has such complete control over the engine that the instantaneous increase of speed as read on the tachometer, or of the voltage as read on the voltmeter, does not exceed 25 per cent., and this is immediately brought down to an increase of 3 per cent., which forms the actual range of speed when the load is gradually removed. The speed of the engine can be regulated by means of a hand-wheel whilst running. Within the flywheel are two pivoted weights. Round a pin in the centre of each is passed a chain; this chain is taken round two pulleys so as to change its direction at right angles, and finally round a central shackle on the axis of rotation. Concentric with the axis are fixed two spiral springs, and as the pivoted weights move outwards by centrifugal force the springs are compressed by a plate attached to the central shackle. Of the two springs the outer is enclosed within a revolving sleeve centred on an inner sleeve containing the inner or main spring; by means of the hand-wheel the outer sleeve can be moved backwards or forwards, compressing or relaxing the outer or supplementary spring; thus the combined strength of the two springs, resisting the tendency of the weights to fly outwards by centrifugal force, is altered, a different position of the eccentric ensues, and in consequence the speed of the engine is altered. Full details of this method of regulation will be found in Messrs. Allen's patent No. 10,305 of 1891.

Messrs. W. H. Allen and Co. have now supplied a group of five exciters for the Deptford Central Station.

APPARENT MAGNETIC RESISTANCE AND CONDUCTIVITY.*

BY CHAS. STEINMETZ.

If we subject a magnetic circuit of any kind to a magnetomotive force F, this magnetomotive force F produces a "magnetic current," that is, a certain number of lines of magnetic force M, and as the *magnetic resistance or reluctance* of the circuit we define the ratio $P=\frac{F}{M}$; as its magnetic conductivity or permeability, the inverse value, $\mu=\frac{1}{P}=\frac{M}{F}$.

As is well known, in magnetic circuits consisting wholly or partly of iron, &c., the magnetic resistance P and hence the magnetic conductivity μ is a variable quantity, and depends largely upon the density of the magnetic current; that is, upon the number of lines of magnetic force passing through the unit of cross-section.

No entirely satisfactory mathematical equation being known for the dependence of the magnetic resistance, and therefore the magnetic current, upon the magnetomotive force, this dependence has for practical use to be plotted in curves; usually in such a way that the abscissæ represent the magnetomotive forces F, preferably in ampere-turns per centimetre or per inch length of the magnetic circuit, while the ordinates represent the magnetic current density in kilolines per square centimetre, or per square inch, as shown in curve I. of the accompanying diagram.

The magnetic conductivity has a simple geometrical meaning in the characteristic magnetic curve also. Connect any point x of the curve I with the starting point o, then the tangent function of the angle ϕ between this line x o and axis of abscissæ o A is the magnetic conductivity at the point x:

$$\mu=\frac{M}{F}=\tan\phi=\tan x\,o\,A.$$

This allows us to survey the variations of the magnetic conductivity μ by following the radius vector o x, when x travels on the characteristic curve from its starting point to saturation.

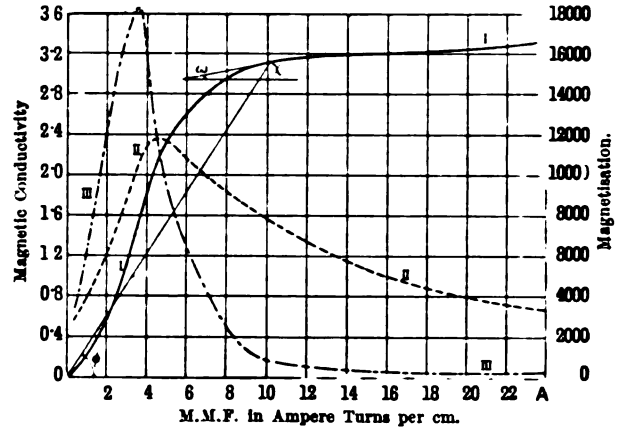
We see that the magnetic conductivity is first a minimum, $\mu_0=\tan\phi_0=500$, and then increases up to a maximum, $\mu^1=\tan\phi^1=2{,}320$, for the tangent point of the tangent drawn from o upon curve I.; and then decreases again, reaching 640 for the magnetomotive force F = 24. This value of the tan ϕ has been plotted in curve II., the susceptibility curve, and shows plainly the rise up to a maximum, and then the decrease again.

But we derive still another tangent function from the magnetic characteristic. In drawing at any point x of the curve I. a tangent to this curve, this tangent forms an angle ω with the axis of abscissæ, or with any other horizontal line. The tangent function of this angle ω is what I call the *apparent magnetic conductivity at the point x*. This apparent magnetic conductivity is often of even greater importance than the true magnetic conductivity. It is the magnetic conductivity which a magnetomotive force meets when acting upon a magnetic circuit magnetised already up to the point x by another magnetomotive force.

Let, for instance, a magnetic circuit be magnetised by the magnetomotive force F = 6 ampere-turns per centimetre, which produce the magnetism M = 12·95 kilolines, per square centimetre. Introducing now in this magnetic circuit a further magnetomotive force of $f=1$ ampere-turn, this magnetomotive force, superposed upon F, will either increase or decrease, according to its direction, the magnetism M produced by F, to 13·08 or 12·82 kilolines respectively; that is, the magnetomotive force $f=.1$ will produce an additional magnetism, $m=.13$, superposed upon the magnetism M = 12·95, caused by F = 6, and hence the magnetomotive force f will meet with an apparent magnetic conductivity of $\delta=\frac{m}{f}=1{,}300$, while the true magnetic conductivity at this point is:—

$$\mu=\frac{M}{F}=2{,}160.$$

This apparent magnetic conductivity will be of importance in all cases where another magnetomotive force is superposed upon a magnetised circuit, as, for instance, in the compound dynamo, in which the magnetomotive force of the series coil is superoposed upon the shunt magnetomotive force; or in the dynamo alternator in which the pulsating armature magnetomotive force is superposed upon the constant field magnetomotive force. This apparent magnetic conductivity is much more variable than the true magnetic conductivity. Twice it has the same value, at the initial point, and at the maximum point of the true magnetic conductivity. Between both points it is larger; beyond the maximum point of true magnetic conductivity it is smaller than the latter, so that it decreases faster than this does.



I., Magnetisation; II., Magnetic Conductivity, μ; III., Apparent Magnetic Conductivity, δ.

Following the variations of the tangent of the characteristic curve I., we see the apparent magnetic conductivity—plotted in curve III.—start at the same point, 500, as curve II., but rise very rapidly up to a maximum value of 3,700, for the magnetisation M = 7·25 corresponding to a M.M.F., F = 3·5, then decrease again just as rapidly, intersect II. at 2,320, and rapidly decrease to 100, for F = 12, then decreasing very slowly down to 40, for F = 24. It is interesting to note that at about 2·5 ampere-turns the apparent conductivity is more than twice as large as the true conductivity, while at about 14 ampere-turns the apparent conductivity is already less than one-fourteenth of the true conductivity.

Of still more importance than for the design of continuous-current dynamos is the consideration of the apparent magnetic conductivity in alternating-current dynamos. For in the alternator the armature reaction upon the field is well known to be usually much larger than in the continuous-current dynamo, because of the very sudden fluctuations of the armature magnetism. At the same time, for the constant potential alternator a small armature reaction is of more importance even than for the continuous-current dynamo, because the alternator has, besides the drop of potential due to armature resistance and to self-induction, still another cause for a drop of potential with increasing load, which the continuous dynamo current has not. Now, every time that an armature coil passes in front of a field pole, the current flowing at this moment in the armature coil, throws a magnetomotive force into the magnetic field circuit, which is magnetised by the exciting current. In consequence

* From the *Electrical Engineer* of New York.

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thereof, the magnetic field circuits are acted upon by two magnetomotive forces, namely, the magnetomotive force of the exciting current, which is supposed to be constant, and the fluctuating magnetomotive force of the armature current. This latter magnetomotive force, if of considerable influence, will not only cause the field magnetism to fluctuate also, and to be a minimum, where it is needed most for inducing electromotive force—thereby changing the shape of the current wave from the true sine shape to a more ragged appearance—but this fluctuation of the field magnetism will induce an alternating electromotive force in the exciting circuit, which, besides causing the exciter dynamo to spark, wastes quite a considerable amount of energy.

From what has been said it is obvious that, to keep the fluctuations of the exciting current of an alternator down as much as possible, the field magnets have to be magnetised up to that point of the magnetic characteristic, at which the apparent magnetic conductivity is very low. For instance, employing iron of the characteristic shown in the diagram, when magnetising the field with a density of 15,000 lines of magnetic force per square cm, in spite of the larger number of exciting turns the fluctuations of the field current will be reduced to about one-twelfth the value they have when the field is magnetised with 8,000 lines per square cm. The fluctuation of the field magnetism will even be reduced still more. In practice, indeed, these fluctuations of the exciting current are somewhat decreased in many cases by eddy currents set up in the field iron. But to rely upon eddy currents in the iron is certainly anything but an economical way of dynamo building.

REVIEWS.

Chemical Theory for Beginners. By LEONARD DOBBIN, Ph.D., and JAMES WALKER, Ph.D., D.Sc. (London: Macmillan and Co.)

The authors state in their preface that their object has been to assist beginners in obtaining an elementary knowledge of the principles upon which modern chemistry is based, and they may be congratulated on the success of their attempt to write a book which shall serve as an introduction to the writings of Mendelejeff, Lothar Meyer, and Ostwald, and at the same time be comprehensible to the beginner. The smaller textbooks usually treat theoretical matters so lightly that the student has small opportunity of obtaining any satisfactory grasp of these during the earlier portion of his studies; while in the larger treatises the same subjects are not dealt with very fully, because the student is supposed to have been introduced to them already. Chemical formulæ are the outcome and embodiment of many facts and theories, and therefore their full significance can be appreciated by the more advanced student only, although their use is necessitated at a very early stage. In this book the nature of the facts on which the theories are based are clearly set forth, and as the experiments have been carefully selected, the student who works through these should find little difficulty in following more advanced treatises. It will probably surprise many to find the modern theories of electrolysis, mass action, and dissociation introduced into a work which purports to be of an elementary character, but since Arrhenius in 1887 developed the Clausius hypothesis and brought it into the quantitative form which is now called the theory of electrolytic dissociation, so much work has been done on the subject that many, besides beginners in chemistry, will be glad of a succinct, non-mathematical account of the views which are now attracting so much attention, and of the reasons for them. The practical applications of electrolysis are daily extending, and with the increase of our knowledge of the conditions under which electro-chemical reactions take place, we may expect a still more rapid extension; and therefore a work of this sort is to be commended which opens to the general reader a branch of science that is usually regarded as a preserve of the mathematician.

Die Elektrischen Accumulatoren und ihre Verwendung in der Praxis. By J. SACK. (Wien: A. Hartleben.)

This book is interesting as the work of a telegraph engineer, since it calls attention to a wide field for the employment of secondary batteries, too apt to be overlooked, although they have been employed by the British authorities almost since their first introduction commercially, and many of the early pioneers in the development of the secondary cell were telegraph men. The arrangement of the book follows the natural development of the cell, that is to say, a brief summary of the early experiments on polarisation effects noticed by Ritter and others is given, followed by a short description of the leading batteries up to the time of Planté. The theory of the Planté cell is then discussed, and the principal modern developments of the accumulators are dealt with. There is a good chapter on the various methods which have been suggested from time to time for the automatic regulation of charge and discharge, and there is also a summary of the more important uses to which the cells have been, or might be put, with the best arrangement for the various purposes. There are numerous illustrations.

Notes on Design of Small Dynamo. By GEORGE HALLIDAY. (London: E. and F. N. Spon.)

Although the small dynamos described in this book are little else than toys, the principles of their construction are discussed with care and in a very methodical manner. The author feels the want of names for magnetic units. Instead of contenting himself with an explanation of the mode of measuring and expression of the strength of a magnetic field, he must needs name the unit. Finding the symbol H to hand, he coins the word "Hop." As an example, we read on p. 36, "Find the ampere turns necessary to produce ·0000115 Hops per square inch in a cast-iron circuit 12 inches in length and 4 square inches in area." This might just as well have been written, "Find the ampere turns necessary to produce a field of ·0000115 per square inch," or "a field of a strength of ·0000115 per square inch," &c. In any case the reader must note the way in which the author proposes to measure the strength of field. Without any explanation that we can find, and there is no index to assist the search, the name "kapp" is used apparently to denote the same unit as a "Hop." One is about as bad as the other, and there is an invidious use of a small initial letter in one case, and a capital in the other. "Why be-little pioneers?" The chapter on the bearings of dynamos savours too much of the lecture-room; not a word is said about the side pull of the magnets on the armature.

Inter-Communication in Railway Trains; Means of Communication between Intermediate Places and Stations; Means of Communication between Trains while on the Journey. Papers by H. POLLITT, read before the International Congress on Railways at St. Petersburg, June, 1892.

These three Papers, by Mr. H. Pollitt, of the Manchester, Sheffield and Lincoln Railway, contain descriptions of the many ingenious mechanical and electrical appliances which are in use in railway work. The first of these, dealing with methods of communication between the passengers and the staff in charge of the train, discusses the cord, electric, and mechanical or pneumatic systems. The author finds that the electrical methods are liable to defects arising from the numerous contacts and surfaces which are very seldom used.

The second Paper, which is copiously illustrated, gives a brief and rather scant account of block signalling, mechanical interlockings, electric signalling, telegraphy and telephony. Much of it is so sketchy as to be of little use or interest; the illustrations are by far the best part of the work.

The third Paper describes two methods of telegraphing to or from a moving train, one by means of a trailing contact on an insulated rail, and the other by induction. Both systems appear to have been used with considerable advantage in America.

Spon's Engineers' and Contractors' Illustrated Book of Prices. 1892-3. (London: F. and N. Spon.)

This large and handsome volume is the outcome of a praiseworthy attempt to collect a great number of price-lists and catalogues into a convenient form. An index of subjects and one of names is provided. As far as it goes, this collection is very useful, but only about 112 firms are represented. We hope that the publishers in re-issuing this book will suppress a large portion consisting of mere advertisements, which contain very little information, and will collect together a larger variety of really useful price-lists. The matter does not appear to be classified in any way, as has been done in similar publications for other trades.

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MAGNETIC LAG AND HYSTERESIS.

By degrees, and thanks to purely experimental research, we are becoming acquainted with the magnetic properties of iron, and it may be noticed that all the work which has been done has been of a purely scientific character although the results are of great commercial importance. Iron has been tested for commercial purposes and instruments have been made to facilitate such tests, but up to the present the researches have been carried out with little or no reference to trade considerations. The permeability of iron was recognised as a matter of importance as soon as dynamo building became a branch of engineering, but the hysteresis losses, though of some importance in the armatures of continuous current machines, were not carefully attended to until alternate current dynamos and transformers became common. We publish in this issue an account of an investigation by Messrs. EVERSHED and VIGNOLES on the core losses occurring in transformers. This comes opportunely in connection with Dr. HOPKINSON's Paper on this subject printed in our issue of September 9, since it offers a very likely explanation of the differences, there described, between the hysteresis curves obtained with slow and rapid magnetic cycles. The present Paper is further important, as it appears to dispose of the question of magnetic lag, by showing when, and to what extent, this phenomenon occurs, as far as transformers are concerned. It is evident, from the results given, that the fact is of negligible importance, although as time-lag affects the hysteresis curve to some extent when the magnetism is changed slowly, the hysteresis constants obtained by slow cyclic experiments cannot be considered quite applicable to alternate current work. The slight time-lag which occurs at high frequencies, however, produces an effect which is in the opposite direction to what has usually been supposed, for the lag tends to decrease the loss of energy and, as the phenomenon is more important the slower the cycle is performed, the

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hysteresis loss becomes greater as the frequency is increased. The result may perhaps be best summarised by stating that the hysteresis loss in a cycle is constant for all high frequencies, that it is slightly less for very low frequencies; and that when a single cycle occupies some minutes, the loss may be diminished by as much as 20 per cent.

The magnetic-lag phenomena which occur with slow cycles, although of no importance from an engineering standpoint, is of considerable theoretical interest, and deserve further investigation. It seems remarkable that an effect of this kind which increases the area of the hysteresis curve by as much as 20 per cent. should have so long escaped notice, but a simple explanation at once offers itself. Hitherto these curves have been obtained by the static method in a symmetrical manner, the magnetising current being reversed in order to get the negative part of the curve. Messrs. Evershed and Vignoles do not, however, reverse the current, but use a subsidiary current to supply the negative magnetising force. The experiments, instead of starting from the middle of the curve, as hitherto, always start from one of its extremities. This method was described by Mr. Evershed in the course of the discussion on Dr. J. Hopkinson's presidential address before the Institution of Electrical Engineers, but the use of the constant current was not clearly understood at the time. A brief discussion, which is not recorded in the Journal of the Institution but which was alluded to in our report of the meeting, took place on this point. Profs. Ayrton, Perry, and S. P. Thompson could not elicit, either from Mr. Evershed or from Mr. Vignoles, who came to his assistance, the object of using two magnetising circuits. Since then, however, the method has been clearly described in the article by these authors, which appeared in *The Electrician* of October 16, 1891, and of which their present contribution is the sequel. Mr. Evershed alluded to the results which they had obtained in the course of the discussion which followed Mr. Alex. Siemens' Paper on February 25th, 1892, but he did not enlarge upon them, as an early publication of their work was intended. But on April 8th, 1892, we printed an article by Prof. J. J. Thomson on the heat produced by eddy currents, and Messrs. Evershed-Vignoles found that his final result for currents in a thin plate was four times greater than theirs. It remains to be seen where the discrepancy arises, but in the meantime, after delaying publication for several months, their experimental work has been confirmed, and we hope that, as on the former occasion, these authors will be able to hold their own. The apparatus used by the experimenters was very small, the over-all dimensions of the transformer being about four inches, but the phenomenon under investigation merely depended on the frequency and the induction density, and could be most conveniently tested with small apparatus. The object was not, as in the experiments of Mr. Mordey and many others, to examine the action of a transformer, but to test the properties of iron; and it is to be observed that we here have a full account of careful tests by two different methods on the same piece of iron.

Much more commercially important than the effect of magnetic lag is the observation of the authors that two samples of charcoal iron obtained from the same mills, sold as the same quality, and having the same permeability, may differ in their hysteresis losses by more than 70 per cent. from each other. This serves to explain the widely diverging results of tests of this material published by Messrs. Ewing, Siemens, Dobrowolsky, and Hopkinson. The conclusion seems to be that published tests of hysteresis losses, however carefully the experiments may have been performed, cannot be relied upon as being applicable to other samples of the same nominal quality. In our review of Prof. S. P. Thompson's "Dynamo-Electric Machinery" it was suggested that a word of warning might have been introduced against the use of mild steel, and Mr. Kapp wrote to ask why mild steel should be avoided. As was then explained, mild steel was not impeached, but the description was so vague, that very undesirable qualities might be included by the iron merchant, without any thought of the consequences. It appears now, that even charcoal iron is liable to the same differences in magnetic quality, and if this be the case, it becomes a matter of the highest importance that chemical analyses be made, and the real causes of difference traced. In the absence of further information which would be difficult to obtain, there is a strong probability that real charcoal iron has small hysteresis, and that the minute contaminations which mild steel is liable to absorb during its manufacture, and which are disregarded because they do not sensibly affect the mechanical properties or indeed the permeability, may give rise to serious residual magnetism. We understand that in America iron manufacturers find it is worth while to cater for the requirements of dynamo and motor builders, but these two trades are of a very different relative importance in this country, and the right quality could be more easily obtained if electrical engineers could describe their wants in ordinary metallurgical terms.

THE MEASUREMENT OF HYSTERESIS AND EDDY-CURRENT LOSSES IN TRANSFORMERS.

BY SYDNEY EVERSHED AND ERNEST B. VIGNOLES.

II.

In our first article* we have described a method by which the loss of power in the core of a transformer may be measured by the rise of its temperature; and the first application we made of it, namely, to determine whether a cross-induction, applied to an alternately magnetised ring, diminished the loss by hysteresis, gave such exceedingly concordant results as to enable us to determine within very narrow limits the waste of energy in an iron core; and we therefore determined to use the method for a preliminary investigation of the subject of viscous hysteresis.

This is a subject which has long engaged the attention of physicists, but we found the current ideas on the subject in a somewhat nebulous condition. Profs. Ayrton and Perry, in their Motor Paper of 1883, came to the conclusion that they had distinct evidence in the displacement of the field in a motor, of the existence of viscous hysteresis to a very appreciable extent; and to this view they have always adhered. Others, however, have denied the existence of viscous hysteresis of an appreciable amount, explaining the Professors' results as effects of armature reactions and eddy currents in the core.

The first evidence which was published on the subject, so far as we know, was the experiments of that indefatigable worker in this field, Prof. Ewing, who showed that when iron was subjected to weak magnetising forces, the amount of induction continued to increase for some minutes after the application of the force.

But before this, other experiments on this subject had been made by Mr. C. J. Barley at the Central Institution, in which a ring of iron was rotated above the poles of an electro-magnet in the field of which a permanent magnet hung with its poles immediately over the rotating ring. Eddy currents were eliminated as far as possible by lamination, and air currents by suitably screening the suspended needle; and the result was to show that in addition to the displacement in the field caused by static hysteresis when the ring was slowly turned, there was a further displacement in the same direction when the ring was rotated at speeds corresponding to a frequency of about 100 $\sim$ per second or more; and Mr. Barley attributed this to viscous hysteresis. The experiments do not appear to have led to quantitative results, and can hardly be regarded as conclusive.

* *The Electrician*, Vol. XXVII., No. 664, October 16, 1891.

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Theoretically it would appear probable that as even molecules must have some inertia, time must be taken to move them; but it was obviously a question whether in a transformer worked by an alternator at, say 100 ∿ per second, the time taken for the induction to pass from zero to its maximum value—about 1/400 of a second—was enough to make a serious difference in the amount of induction produced by a given magnetising force.

Prof. Ryan, whose curves from actual transformers would have been the most valuable practical contribution to the subject ever published, had he given full details and dimensions of the transformers used,* gave in his Paper a curve of losses in his iron in which eddy currents were included with hysteresis. This curve may be seen in the articles on Transformers by one of the authors in *The Electrician*;† and Prof. Ryan, comparing this curve with Ewing's, concluded that there "was no room for viscous hysteresis." He however appears to assume that his iron was identical in quality with that tested by Prof. Ewing, a somewhat unwarrantable assumption, as we shall presently show.

Such was the state of our knowledge of the subject when in March, 1891, we made a discovery which gave us some hope of finally settling the question.

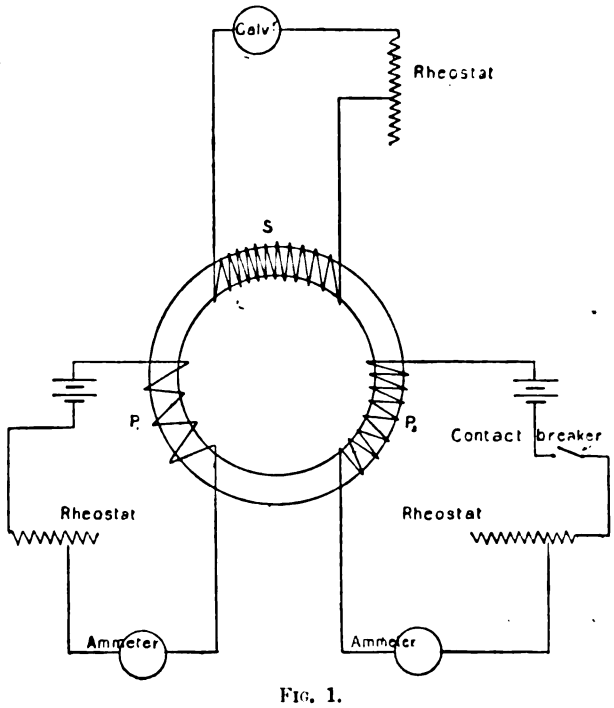

Fig. 1.

In order to explain this clearly, it is necessary to refer to the Paper read by one of the authors in May, 1891, to the Old Students' Association of the City and Guilds of London Institute.‡ A very full description of our method of testing iron is given in this Paper, to which we may refer any one who cares for fuller information. Briefly the arrangement is this: The ring of iron is wound with two superposed primaries, in one of which, P_1 (*see* Fig. 1), a constant current is maintained; in the other, P_2, a magnetising force is produced in the reverse direction; so that by making and breaking this circuit the iron can be carried practically instantaneously through an induction cycle, starting from and returning to the lowest point of the curve. Now by consulting Fig. 2 it will be seen that observations on the rising curve can be taken by simply making a current in P_2, thus obtaining the ordinates AB, CD, &c.; and since our galvanometer takes about one second to make its swing, its period being 3·8 seconds, it follows that all the observations on the *rising* curve give the *integral of the Induction up to one second after the application of the magnetising force.*

Not so with the falling curve. In order to get on to this curve, it is necessary to put on the current P_2 at its maximum value, decrease to the value required, wait to read the ammeter (these operations taking perhaps half a minute), and then *break*.

Consequently if the induction lags in time behind the magnetising force, it has time to *creep down* during these processes, and we should naturally expect it to creep most at the steep parts of the curve; therefore, the net result should be a difference in shape between the rising and falling curves; the falling curve being more perpendicular to the axis of H than the other, and enclosing less area. This consideration was forced upon us by

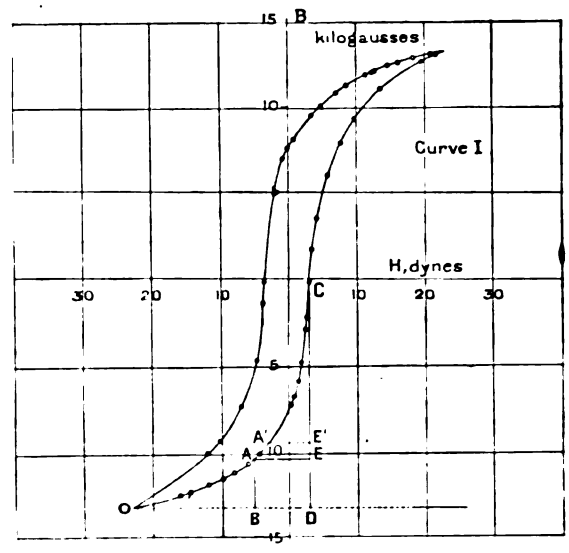

Fig. 2.—Method of obtaining Ordinates of Cyclic Curve.

the study of our curves, in many of which this phenomenon is most noticeable. In the Paper read to the Old Students' Association, already referred to, the cause was hinted at; but as we then had no further evidence, we had not the confidence in the explanation which we now possess.

The difference between the work done if the induction were forced through its cycle in about two seconds, and that which

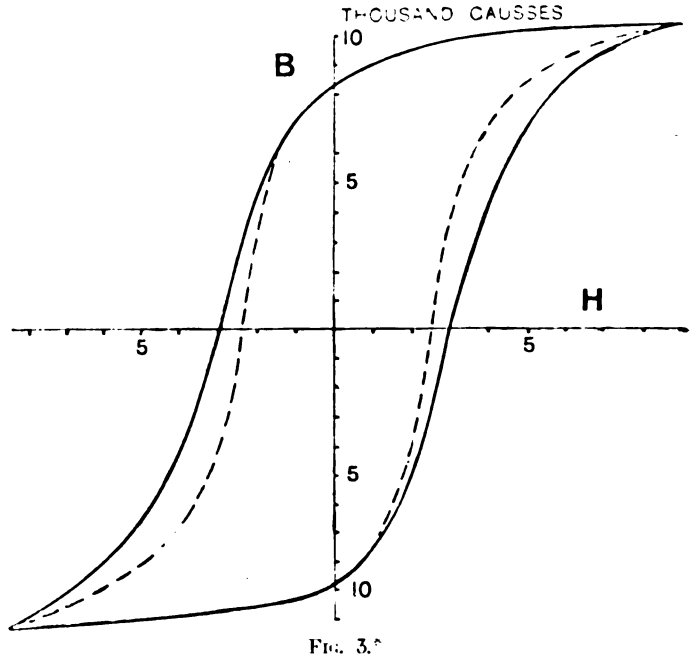

Fig. 3.*

would be done if the time taken were very large is considerable. The curve given here, Fig. 3, is a good instance. The full line is the curve when the integral of the induction up to one second after the application of the magnetising force is taken as the ordinate, while the dotted line shows the area

* Why *do* people invariably leave out the most essential information?

† Vol. XXVI., p. 724, April 17, 1891.

‡ *The Electrician*, Vol. XXVII., p. 50, May 15, 1891.

*As no names have yet been given to the units, we have been compelled to invent our own:—

1 Thom = 1 C.-G. S. unit of induction.

1 Gauss = 1 Thom per sq. cm.

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when a comparatively long time, perhaps half a minute, is allowed to elapse between the application of the force and the measurement of the amount of induction. The difference in the areas amounts to 19 per cent. of the smaller curve. It will be understood that this particular curve is an extreme case; but it is noticeable that all our curves give losses larger than those given for similar materials in Prof. Ewing's tables.*

All curves except ours have been taken by static methods† which would give the area of the dotted curve; and if the difference between the work done in the two cases mentioned is so great, why should it not be far greater when the time occupied is only $\frac{1}{100}$th the part of a second? Indeed it seemed highly probable that the difference might be very considerable, and preliminary experiments had led us to anticipate that a difference of 50 per cent. was not unlikely. Obviously to determine the point it was necessary to measure the power wasted when the transformer was run on an alternating current, and compare it with the loss when put through the same cycle comparatively slowly.

That such a comparison is not without commercial value the following considerations will show. The number of lamps on the circuits of the alternate current supply companies in London alone must exceed the equivalent of 120,000 thirty-watt lamps. The transformers running these are mostly small in size, and it takes at least 5 per cent. of their full load output to excite them; hysteresis losses being responsible for 80 per cent. of this. The money value of this power—170 units per hour—to the supply companies, cannot be less than £10,000 a year, money which is being absolutely thrown away, and any inquiry into the causes of this waste cannot but be of commercial importance. Observe that in this calculation the efficiency of the transformers has been based on the assumption that the *static* curve gives the hysteresis loss; it follows, therefore, that if there were an additional waste amounting to anything like 50 per cent., another £5,000 at least would have to be added to the above figure. But, apart from this, the question is one of considerable scientific interest.

We will now proceed to describe the experiments by which the point may be settled. The first and most satisfactory method is the use of a watt-meter. If the back electromotive force of the pressure coil is kept very low, and no metal in any part of the instrument is allowed to produce eddy current errors, the method is, of course, perfectly accurate. Such a watt-meter, however, takes time to construct, and we were impatient to have some information on the subject; we therefore determined to make preliminary experiments by the thermometric method.

The process was as follows: The actual rate of rise of temperature, corrected for cooling, was determined, and then compared with the rise predicted from the following data:

(1.) The area of the B.H. curve taken from the actual piece of iron used.

This gives the watts spent in hysteresis, when the iron is going through its cycle once in about two seconds.

(2.) The watts spent in eddy currents in the iron from the mean induction density. This waste is so small compared with the amount of energy lost by hysteresis that no elaborate mathematical treatment is required.

From 1 and 2 we get the rate of conversion of energy into heat.

The specific heat of the transformer should also be determined, and we are then in a position to predict the rate of heating—when no cooling takes place—and on the assumption that the area of the B.H. curve is the same for such widely different frequencies as 100 $\sim$ per second and 0·5 $\sim$ per second. Any difference between predicted and observed effects may be set down to viscous hysteresis.

The Transformer.

The transformer was built up of twenty charcoal-iron circular stampings, the inner diameter of which was 4·15cm., outer diameter 9·25cm. The mean thickness of each stamping from 40 measurements was ·0414cm. Embedded in the core thus formed was the bulb of a clinical thermometer, having a range of 10° – 35°C. in tenths of degrees, and capable of being easily read to 0·025°C.

A secondary circuit of 300 turns was wound evenly all round the ring for the purpose of measuring the induction in conjunction with a Cardew voltmeter. The primary winding consisted of one straight cable, on which the transformer was threaded, without touching it at any point. The idea of this precaution was to render the heating due to C^2R in this cable of as little importance as possible.

The following table contains complete dimensions, &c. worked out from the above data:—

Transformer.—

Area of section across induction path	= 2·12 sq. cm.
Average length of induction path.....	= 21·02 cm.
Volume of iron	= 44·55 cc.
Weight of transformer including secondary	= 377 grammes.
Secondary circuit	– 300 turns.
,, resistance	= 7·5 ohms.
Resistance of Cardew voltmeter	= 55 ohms.
Effective E.M.F. in secondary circuit	= Reading of Cardew $\times \frac{(55+7\cdot5)}{55}$

Measurement of Specific Heat of Transformer.

Since the specific heat of iron is known to lie between 0·11 and 0·12, it was easily determined with sufficient accuracy in the following manner:—The transformer was heated to 100°C., and the total rise of temperature produced by immersing it in a vessel containing a certain weight of water at a known initial temperature, was compared with that produced by a known weight of boiling water when mixed in the same vessel with the same amount of cooling water at nearly the same initial temperature. Since we know that somewhere about 0·11 of the weight of transformer must be the weight of the water added to obtain the same rise of temperature, the two experiments are easily made practically identical as regards cooling; the same vessel being used and the air temperature being constant.

The transformer, being built of iron plates insulated with thin paper, naturally carried over from the bath in which it was heated a considerable amount of water; and it is in the weight of water occluded that the greatest chance of variation occurs. Several measurements, however, showed that the variations in weight, on lifting the transformer from the water bath, were within the limits of accuracy required.

Put algebraically, if

w = weight of dry transformer,
v = ,, ,, water occluded,
W = ,, ,, ,, in cooling vessel,
g = ,, ,, ,, used for comparison in second experiment.
x = specific heat of transformer,
y = ,, ,, ,, water,
T = initial temp. of transformer, i = ,, ,, ,, bath ..... } in Expt. I.,
t = final temp. of iron and bath
T = initial temp. of water used for comparison, J = ,, ,, ,, bath ..... } in Expt. II.,
θ = final temp. of both .....
q = heat lost by radiation and convection from bath,

then the equation

Total heat before immersion = total heat after immersion + quantity lost, or—

$$wx\mathrm{T} + vy\mathrm{T} + \mathrm{W}yi = wxt + vyt + \mathrm{W}yt + q. \quad . \quad (1)$$

represents the result of the first experiment, the second experiment being of course necessary to eliminate q.

The corresponding equation for the second experiment is—

$$gy\mathrm{T} + \mathrm{W}yj = gy\theta + \mathrm{W}y\theta + q \quad . \quad . \quad . \quad (2)$$

Since the conditions as to cooling during the rise of temperature of the bath are practically identical, no appreciable error can be caused by assuming the quantity of heat lost, q, to be the same in both experiments.

* Vide *The Electrician*, Vol. XXVI., No. 614, March 20, 1891.
† Since this was written Dr. Hopkinson has become a convert.

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Eliminating q from equations (1) and (2), and writing $y=1$ we find the value of specific heat of the transformer compared with water, viz. :—

$$x=\frac{W(t-i)+g(T-\theta)-W(\theta-j)-v(T-t)}{w(T-t)} \quad . \quad (3)$$

Substituting the following values in this equation :—

W = 10,630	grains	T = 100°C.
g = 1,080	„	i = 12·7°C.
v = 675	„	t = 21·4°C.
w = 5,815	„	j = 12·2°C.
		θ = 19·3°C.

we arrive at the value

$$x = 0{\cdot}112 \text{ gramme-degree-centigrade.}$$

Remembering that 4·2 joules = 1 gramme-degree-centigrade, we find the specific heat of the transformer to be

$$4{\cdot}2 \times 0{\cdot}112 = 0{\cdot}47 \text{ joules.}$$

It is evident, therefore, that the insulating tape and paper and the copper secondary circuit have practically no effect on the value of the specific heat, which is generally given in text-books as 0·112 for soft iron.

The transformer was then taken to pieces, dried, and rebuilt, Experiment I. having reduced it to a sloppy mass.

*Measurement of Waste of Power.**

The order of procedure was as follows :—Having previously calculated the volts on the Cardew which would be produced by a maximum induction-density of 10,000 gausses,† the primary current was started and raised as rapidly as possible to a value giving the required reading on the voltmeter. We may note that this adjustment must be made exceedingly quickly, as the range of the thermometer is short and the whole of the heating curve is taken in less than 10 minutes.

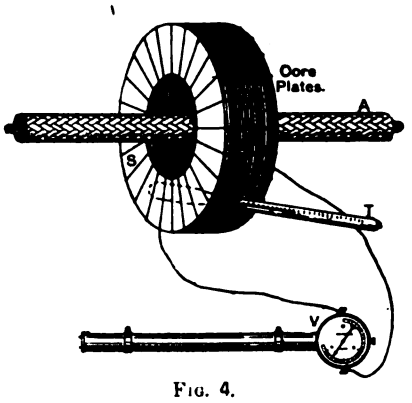


Fig. 4.

Observations are taken by two experimenters of the times at which the transit of the mercury over each degree of the scale takes place ; while a third keeps the speed of the alternator constant ; a small adjustment being made from time to time of the primary current as the circuits rise in temperature.‡ When the thermometer is about to reach the top of its scale, the primary and secondary currents are rapidly replaced by direct currents of the same effective value ; and time readings of the thermometer are taken as the transformer cools. As the rate of cooling depends on the difference of temperature between the transformer and the air, frequent observations must be made of the air temperature in the neighbourhood.

It may not be without interest to compare this method with other thermometric methods which have been used or proposed for the purpose. Mr. Mordey attempted to determine the final temperature, and to do this he had to maintain the power supplied to the transformer and the frequency constant for many hours, encountering additional difficulties in the variation of the temperature of the air and surrounding objects, accentuated by the use of a "shilling thermometer." Prof. Ewing, on the other hand, has suggested* the use of a thermo-electric couple in place of the thermometer, but we should anticipate difficulties from currents induced in the thermo-electric circuit. Mr. Alex. Siemens has recently published some measurements of the power wasted in a transformer core, determined from observations of two temperatures, giving two points on the curve corresponding to our curve J ; thus making a great advance on the somewhat crude method of observing final temperatures. The method we used, similar in principle, gives however ten or twenty points

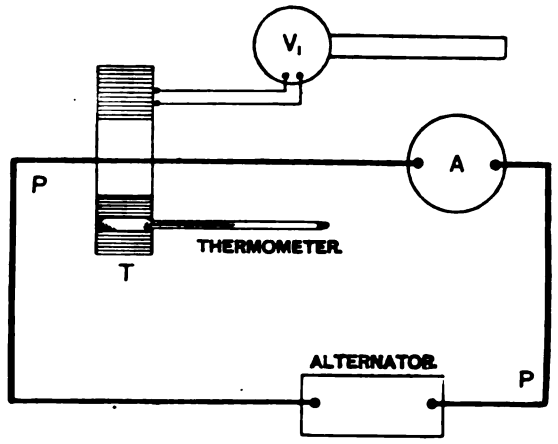
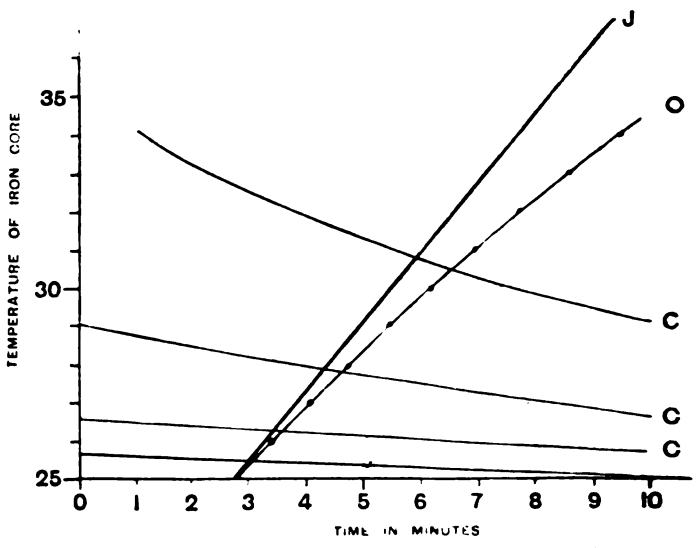


Fig. 5.

on the curve in the space of ten minutes, the discrepancy of these affording an excellent criterion of the accuracy of observation. Moreover, the use of an accurate thermometer gives the temperature without further complication, and it is much easier to determine a number of times by the observation of the transit of the mercury over successive divisions than by measurement of a series of resistances.

Fig. 4 is a perspective view of the arrangement we adopted, the circuits being arranged as shown in Fig. 5. The transformer in the present case is laminated in the plane of the ring, and not as shown in Fig. 5.



O. Observed rise of temperature. C. Cooling Curve. J. Corrected rise of temperature.

Fig. 6.—Curves showing Rate of Production of Heat in Iron Core.

The results of Experiment II. are plotted in Fig. 6 where O is the heating curve, C the cooling curve When the former is corrected for cooling in the manner described in our first article the curve J is obtained, indicating the rate of heating which would take place if no cooling occurred ; in other words, the rate of conversion of energy in the core of the transformer.

The power spent in the core (in watts) is obtained from J in the following manner :—Experiment I. shows that the work

* *The Electrician*, Vol. XXVII., No. 664, October 15, 1891.

† Our "gauss" is 1 Thom per sq. cm., and has no connection with the gauss of Dr. Fleming ; and less still with that of Mr. Oliver Heaviside.

‡ The authors are indebted to Mr. A. Schneider and Mr. A. H. Huss for their assistance in these experiments.

* And has since published some results of experiments by the method.

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required to raise 1 gramme of transformer 1°C is 0·47* joules.

Multiplying this into the weight of the transformer, viz. 377 grammes, gives 177 joules required to raise the transformer 1°C. The rise from curve J is found to be 0·0305°C. per second; and, therefore, the number of joules per second (watts) converted into heat is 177 × 0·0305; or *5·4 watts.*

Experiment II.—*Heating and Cooling Curves.*

(*a*) *Heating.*—Frequency = 100 ∿. Secondary volts on voltmeter = 24·8. Air = 15°C. Primary current = 198 amperes.

Time.	Temperature of Transformer.	Time.	Temperature of Transformer.
H. M. S.	°C.	H. M. S.	°C.
5 28 1	22	5 32 27	29
5 29 12	24	5 33 9	30
5 29 48	25	5 33 55	31
5 30 27	26	5 34 45	32
5 31 5	27	5 35 33	33
5 31 45	28	5 36 24	34

(*b*) *Cooling.*—Secondary and Primary Currents Replaced by Direct.

Time.	Temperature.	Time.	Temperature.
H. M. S.	°C.	H. M. S.	°C.
5 38 46	33·5	5 52 47	28· 0
5 39 25	33·0	5 54 55	27· 5
5 41 6	32·0	5 58 45	27· 0
5 43 18	31·0	6 4 4	26· 5
5 44 33	30·5	6 9 55	26· 0
5 45 50	30·0	6 36 0	25·25
5 47 11	29·5	6 37 40	25· 0
5 48 54	29·0	6 40 50	24· 0
5 50 47	28·5	6 44 12	23· 0

(*To be concluded.*)

GEARING.

BY E. TREMLETT CARTER.

(*Continued from page 561.*)

Flywheel Details.

We have seen in the last article that a flywheel must possess a certain moment of inertia, which is determined by the work it has to do, and that this moment of inertia can be obtained either by having a large mass of metal at a small radius or a less weight at a greater radius. It was remarked that in practice the radius of the rim is not allowed to exceed that value which would allow the rim to have a certain velocity when the engine was turning at its fastest rate. We have now to consider the reasons for these limitations, and why it is advisable to adopt certain rules in proportioning the parts of a flywheel.

If a weight is fastened to the end of a string, the other end of which is held in the hand, the weight being whirled round a circle at a rapid rate, one is conscious of a pull in the string which increases as the rate of revolution is increased or as the radius is diminished. The tension in the string, of which the pull on the hand is but one end, causes an opposite force on the weight. The hand is pulled away from the centre by a force which is called *centrifugal*, and the weight is pulled towards the centre by an equal but opposite force which is called *centripetal*. These two forces constitute a tensile stress in the radial link or string. Every part of a moving flywheel is placed under this tensile stress, and, since cast iron is a very weak and unreliable material when under tension, there arises the necessity for a high factor of safety in the design of this engine detail. We will consider firstly the stresses in the rim of the wheel, and subsequently those in the arms.

In Fig. 15 let the two concentric circles represent an element of the flywheel rim at a radius, r, moving with a velocity v ft. per second, and let b be the breadth of the rim. The rim is made of a material having a density Δ, and a strength per square inch equal to S; the whole mass of the circular element being called M. If we consider any small portion of the rim, subtending any angle $d\phi$ at the centre, and making an angle ϕ with the plane of any given section A B, we find that there is

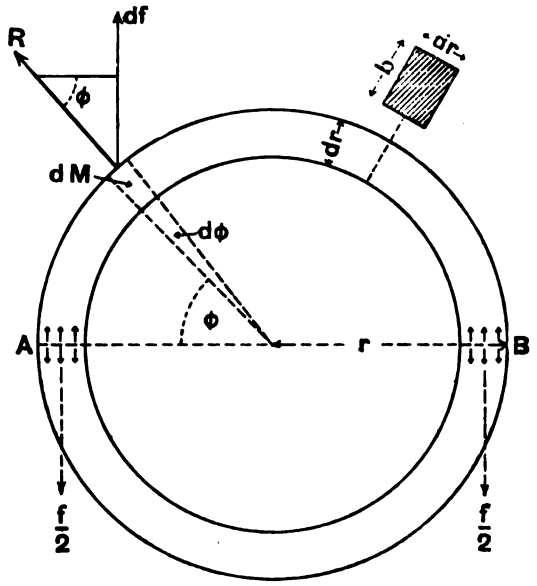

Fig. 15.

a force equal to R acting radially upon it, and that the component of this force at a normal to the plane of section is df, the integral of all the normal forces being f. Then,

$$R = dM \cdot \frac{v^2}{r},$$

and
$$dM = \frac{\Delta}{g} \cdot b \cdot r\,dr \cdot d\phi$$

Therefore,
$$R = \frac{\Delta v^2}{g} \cdot b \cdot dr \cdot d\phi,$$

therefore,
$$df = \frac{\Delta v^2}{g} b \cdot dr \cdot \sin\phi \cdot d\phi$$

and
$$f = \int_0^{\pi} \frac{\Delta v^2}{g} \cdot b \cdot dr \cdot \sin\phi \cdot d\phi = \frac{2\Delta \cdot v^2}{g} \cdot b \cdot dr.$$

Now the section placed under this stress is equal to

$$\text{area} = 2\,b \cdot dr \times 144 \text{ (sq. ins.)};$$

whence the stress per square inch is

$$\frac{\Delta v^2}{144 \cdot g} = \frac{v^2}{10} \text{(approx. for cast iron)}.$$

It is evident that the rim will burst when the velocity is such that this stress becomes equal to the ultimate strength, from which the maximum velocity is

$$v\,(\max) = 12\sqrt{\frac{g\,s}{\Delta}};$$

and the safe velocity is

$$v\,(\text{safe}) = 12\sqrt{\frac{g.f\,\text{safe}}{\Delta}}.$$

It will thus be seen that the safe velocity of a rim is not determined by its diameter or other dimensions, being the same for all sizes and thicknesses of rim if the linear speed is unaltered. One cannot strengthen a rim by putting more metal into it, for thereby the mass is increased and the stress in proportion, the stress per unit of section remaining as before.

The above investigation is applicable only to the case of a rim which is free to assume the circular form at all speeds; and does not, without modification, apply to a rim which is

* See *ante.*

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constrained at several points by practically rigid arms. The following table gives the values of the stress per square inch for different velocities :—

v =	30	40	50	60	70	80	90	100	110	120 ft. per sec.
f =	90	160	250	360	490	640	810	1000	1210	1440 lbs. per sq. in.

It is difficult to see why so small a stress at comparatively high velocities is so frequently accompanied by rupture of the rim. With disc wheels the constraint is uniformly distributed over the rim, yet these are as liable to burst as the wheels with a limited number of arms. In the latter there is, of course, a stress which is not found in the former, on account of the bulging out of the segments between the arms ; this causing a more or less severe bending action on the rim. It is probable, however, that with curved arms this bulging action is not sufficiently severe to account for the tendency of cast iron to burst at low speeds ; and that the cause must be sought in other actions. The writer is of the opinion that the rupture of wheels is due to rapid but transient stresses of considerable magnitude, superposed on a normal stress which has already brought the metal into a state of greatly reduced strength. When cast iron is under tensile stress, even well within the elastic limit, a very trifling jar or vibration will cause fracture. Precisely this kind of momentary stress is to be found in steam and other reciprocating engines, in which, to the ordinary jars of the machinery, are added the variations in effort on the crank shaft. It is advisable to design the flywheel, when it is to be of cast iron, so that the maximum velocity of the rim shall not exceed from 80 to 100ft. per second. Where the speed of the shaft is so high that it is impracticable to keep the rim velocity within this limit, as in dynamo work, it is usual to employ cast-steel flywheels, or to strengthen the wheel by shrinking on iron hoops.

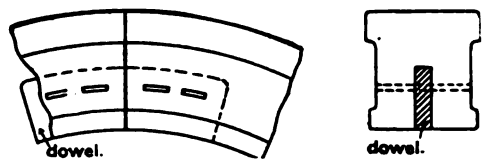

Fig. 16.

When less than 8ft. in diameter, flywheels are usually cast in one piece, but for larger sizes it is found more convenient to build the wheel of a number of segmental castings. If the rim is to be cogged it is not well to cast the teeth on, but to cast them in separate segmental plates, or to mortise them into segmental frames, bolting these on the face of the flywheel. Teeth increase the weight of the wheel without increasing the strength, and consequently necessitate a lower velocity of running. Wheel segments are fastened by several methods, the best of which is known as *dowelling*. A dowelled joint is shown in Fig. 16, which explains itself. The dowel, which is sandwiched into the segments, is of wrought iron or mild steel, and is secured by four through cotters of the same material. Side cover-straps let into the rim are sometimes bolted to the segments ; or a cover-strap is laid on the inside of the wheel at the seam between two segments. A less common and unreliable method consists in shrinking a wrought-iron ring over two lugs, one on each segment, the contracting ring taking a firm grip of each lug and binding the segments together. But the contraction sets up weakening stresses in the ring and renders it unsafe at high speeds. The whole flywheel is keyed to the crank-shaft by means of from two to four steel taper keys sunk into the nave of the wheel and running on flats on the shaft.

The arms of a flywheel are subjected to the following stresses : They have to withstand the dead load of the rim, which causes a tensile stress on the lower and a compressive stress on the upper arms ; they have to resist the tendency of the rim to fly off at a tangent, which sets up severe tensile stresses in all the arms ; and they have to resist the bending actions which arise from the inequality of speeds of the flywheel rim and the shaft, which set up tensile stresses on one half and compressive stresses on the other half of each arm. Formulæ could be deduced for these several stresses, as well as for their aggregate action, but no advantage could be derived from doing so, since no safe rule for the design of the arms would be indicated. In fact, the arms of flywheels are designed from experience, and *not* from theory. It may be mentioned, however, that in small and medium-sized wheels, where the mass of the arms is small compared with that of the rim, the arms should be curved and not radial, in order to eliminate the compressive stress which would otherwise arise on the metal contracting during cooling after casting.

Motor Gearing.

We come now to the consideration of some of the principal forms of gearing which have been used for coupling an electromotor to the machine it has had to drive. As most of these forms of gear have been used for traction purposes, and, indeed, principally so, we shall mainly discuss them in this relation. The various kinds of gearing which have already been considered might, of course, be used for some kinds of motor work ; but it is generally found that a more positive form of force-transmitting appliance, as well as one more compact, is desirable or even essential. In traction work it is absolutely essential that the gearing should be compact, light in weight, durable, simple yet certain in action, free from noise and vibration, and of a reasonable cost. The writer has already, in the introduction, commented on the value of eliminating gearing altogether, but a few remarks may properly be added on the gearless motor. It is hoped that before the readers have arrived at the end of this series of papers they will have seen enough to convince them of the trouble which attends even the best forms of gearing when used on traction motors. Instances will be given of this, and of the defective working of almost every form of motor gear. But the time of gearless motor is hardly yet arrived, and engineers are in most cases compelled to couple their motor to some intermediate mechanism. It is true that the gearless motor is at work, and doing excellent work, on the City and South London Railway ; but the motors there are of exceptionally large power as regards the present development of the branch of engineering, and they are found to be subjected to troubles which could well have been eliminated by the use of gearing. The writer does not advocate the use of gearing on such powerful motor-cars, but is merely pointing out that the absence of it involves the motor armature in dangers which might in certain cases be fatal to success. The experience of the engineers of the South London Railway proves this. Motors without gear cannot well be coupled to the wheels by an elastic cushion or spring, which would take off the shock of the jolts and jars, and are thus liable to have their armatures very severely injured. The frequent burn-outs of the armatures of gearless motors arise largely from this cause. Again, small motors cannot possibly be designed to give the requisite amount of power at low speeds ; so that for tramcars it is still essential to have some form of speed reduction gear and to run the motor at a high rate of revolution.

Steel Spiral Cord Gear.

The first electric tramcar was fitted with this form of gear. This car commenced running in 1881 on the Berlin-Lichterfeld line, and was engineered by Messrs. Siemens and Halske. The motor was coupled to the car axles by means of 27 small steel spiral cords, which ran in V-grooves. Thirteen of these cords drove one of the axles, the remainder driving the other. The centre distance between the driving pulley and each of the axle pulleys was only 2ft. 10½in. ; and the cords were of two strands, $\frac{7}{32}$in. in diameter. This form of gear ran very smoothly and with little loss of power, but it was not found to be positive enough to take the car up a steep gradient ; at starting, a considerable amount of slipping occurred, so that speed was not reached very quickly. The writer does not know of any other traction line on which this gear has been used ; it has been abandoned on the Lichterfeld line, and seems to have only a historic interest. It might, however, well be used in certain cases of stationary motor work, such as in running lathes or sewing machines.

(To be continued.)

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HOLDEN, DRAKE, AND GORHAM'S RECORDING INSTRUMENTS.

The ingenious electrical instruments designed by Captain Holden, which have been heard of from time to time, are now being placed upon the market by Messrs. Drake and Gorham. No less than nine kinds of electrical recording instruments are being brought out—there seems, indeed, to be hardly room for so many varieties—but among them several are likely to meet a real want, and to come into general use. The recording ammeter is of peculiar interest, because the action is so powerful, and the friction of the pen need not cause any trouble. Two metal strips shown in Fig. 1, and diagrammatically by A and B, Fig. 2, are secured to upright supports. The upper one only

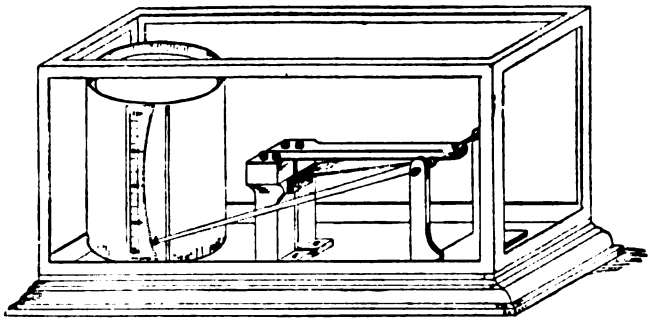

Fig. 1.—Recording Hot-Strip Ammeter.

carries the current, and for this purpose it is slit, the current passing up one side and down the other. The strip B is used only as a tie. The action is shown in Fig. 2.

The two metal strips, A and B, are of the same length. They are fastened together by rivets, at the point E, and also rigidly secured at C and D. If not fastened together at E, they might be supposed to be capable of turning about the points C and D describing the arcs C_1 and D_1, respectively. But, as the strips are rigidly connected at E, if only the upper strip A is caused to extend by a rise of temperature produced in it by the passage of the current, the position which the system of strips will be forced to take up will be one in which the equilibrium is obtained, and this position depends only on the extension of the top strip. For instance, suppose that the amount of extension of the top strip A is equal to the length of the line F G, then the dotted line C G D will represent the position of the system when the strip A has extended by that amount;

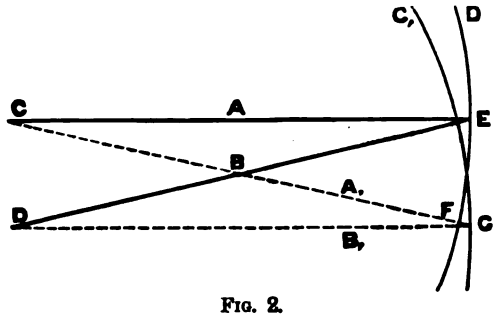

Fig. 2.

it may, therefore, be said that the position is dependent upon a certain current. A rise of temperature in both strips simultaneously, such as would be produced by atmospheric causes, will not affect the system at all, since each strip will lengthen to the same extent independently, and there will be no turning movement.

The record is made on paper attached to a vertical drum revolved by clockwork by means of a pen containing aniline ink, giving a continuous record. The pen is attached by an aluminium arm to an arbor which is turned through a greater or less angle, according to the amount of expansion of the strip. A fixed scale close to the pen enables the amount of current passing at any moment to be read by the eye. This instrument is suitable for either alternating or direct current circuits, and takes little power. As with all such instruments, the scale is not evenly divided. To effect this with an electro-magnetic instrument is almost hopeless, but with a hot strip instrument, the available force is so great that mechanism might be introduced to correct the scale. The advantage of a record with a uniform ampere scale is, that the ampere-hours may be read off direct with a planimeter, giving very useful information in connection with storage batteries. We understand that, though not starting from zero, the scale of the present instrument is fairly uniform.

The feature of the recording voltmeter is its extremely open reading. The electrical portion of the apparatus consists of an open triangular shaped coil shown in Fig. 3 mounted on an arbor working in jewelled mercurial bearings, and moving in a magnetic

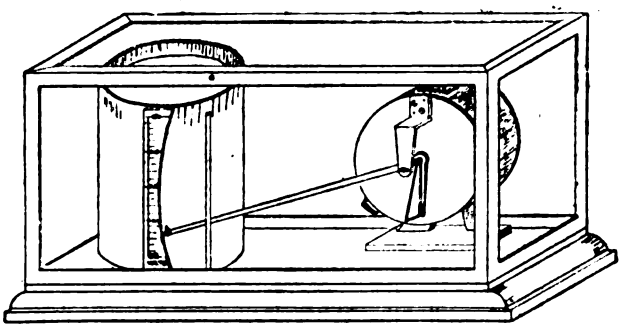

Fig. 3.—Recording Voltmeter.

field. The coil is at first repelled by a radial pole piece, and afterwards attracted by an opposite pole which may be seen in the illustration coming from behind the large coil. The pen is intermittently pressed against the paper by means of an electromagnet in the base of the instrument, worked by means of a main current or by a single separate cell if desired, the contacts controlling this movement are carried by the clockwork in the drum.

It would appear that the Cardew principle was better suited for recording voltmeters than the electromagnetic, for the same reason that we have suggested in the case of the recording ammeter; but Messrs. Drake and Gorham have already tried such an application of the Cardew voltmeter, and it may be presumed that they find the electromagnetic type is more suitable.

Photographic recording instruments, ammeters for direct and for alternating currents, voltmeters and combined voltmeters and ammeters for direct currents are externally all of the same

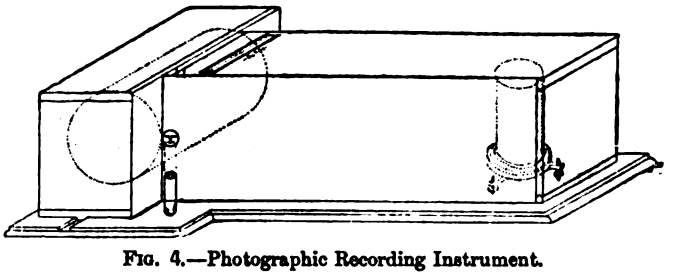

Fig. 4.—Photographic Recording Instrument.

appearance and size, differing only in their internal details. They are about 4ft. long and 18in. wide, and are arranged as shown in Fig. 4.

The revolving clock covered with sensitised paper is contained in a removable box on the left. This box can be removed to the dark room, after closing the shutter, for the paper to be changed and the record developed. The source of light employed may be gas or electric, the beam impinges on the mirror of a Holden D'Arsonval dead beat galvanometer and is therefrom reflected to the surface of the drum; a small portion of the beam is, however, directed upwards and forms a visual pointer on a ground glass scale at the top of the box. The power taken by these instruments does not exceed one watt.

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INVESTIGATION OF THE ENERGY CONSUMED BY INCANDESCENT LAMPS.*

BY CH. HAUBTMANN.

Each type of lamp tested was always represented by a batch of ten connected in parallel and grouped in a row. The lamps were tested at the potential marked by the maker, and at a higher potential. Lamps marked 102 volts were generally taken, and 10 were tested at this potential and 10 similar ones at 110 volts. The current was supplied by a battery of E.P.S. cells, and the total number of amperes, as well as the pressu for each row, was recorded by a Richard instrument. Every 50 :60 hours the lamps were taken down and tested one by one, th. exact consumption and the candle-power of each of them being accurately noted. In this way the curves and tables which follow were obtained.

Table I.—*Lamps 16 c.p., 102 volts, made by the Compagnie "La Française." (Vitrite base. Looped filament.)*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per effective candle.
10	0	15·02	0·44	2·98
10	250	10·00	0·43	4·38
9	500	7·01	0·43	6·25
7	750	6·40	0·43	7·30
7	1,000	5·08	0·43	8·70
		110-volt Test.		
10	0	15·7	0·480	3·36
10	250	13·8	0·475	3·87
8	500	11·2	0·475	4·30
7	750	10·3	0·470	5·20
6	1,000	7·0	0·460	6·40

In the 102-volt test of these lamps it was found that the effective candle-power was always below the nominal figure, and that the light fell off very rapidly after the hundredth hour. There was—

1 lamp destroyed after..... 350 hours.
2 ,, ,, ,, ... 750 ,,
5 ,, ,, ,, ...1,300 ,,
1 ,, ,, ,, ...2,150 ,,
1 ,, ,, ,, more than ...3,250 ,,

The average life may be taken at 1,400 hours. The total energy consumed was between 44 and 48 watts, and the mean candle-power was 8 to 8·5 candles (*bougi s décimales*). The curve (Fig. 1) relates to the lamp which lasted 2,150 hours. In all these curves the full line represents current, the dotted line watts per effective candle, as measured on the photometer, and the chain-dotted line candle-power. The abscissæ correspond to periods of 250 hours, and the ordinates to 0·2 ampere, 2 watts, and 5 candles. In the lamps in question the watts per candle become very large after 250 hours.

In tests at 102 volts of a batch of 10 c.p. lamps of the same make (La Française), one lamp gave out after 400 hours, one after 625 hours, and eight lasted about 1,500 hours. The average life of these lamps may be taken at about 1,000 hours. Their candle-power was sensibly 8 candles. and the energy consumed per lamp was about 36 watts. At 110 volts these lamps had from all points of view a higher efficiency. They steadily absorbed 39 watts during their existence, and their average candle-power was 9·25 candles; however, they gave out somewhat more rapidly than at 102 volts.

Table II.—*Lamp 16 c.p., 102 volts. Siemens. (Brass and plaster base).*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candle.
10	0	19·80	0·550	2·81
9	250	16·00	0·556	3·55
7	500	14·15	0·559	4·00
3	750	12·10	0·560	4·72
2	1,000	11·30	0·561	5·09
		110-volt Test.		
10	0	25·00	0·620	2·70
6	250	16·74	0·630	4·18
4	500	11·35	0·635	6·15
3	750	8·43	0·650	8·40
0	1,000	0	0	0

* Abstract of an article in *L'Electricien* of September 24, 1892.

The average life of these lamps (Siemens) was about 600 hours, the average candle-power 14 candles, and the energy absorbed 61 watts. At 102 volts the lamps gave out as follows :—

1 lamp after 200 hours. 1 lamp after 950 hours.
2 ,, ,, 350 ,, 1 ,, ,, 1000 ,,
1 ,, ,, 500 ,, 1 ,, ,, 1400 ,,
3 ,, ,, 550 ,,

It may be observed that these lamps differed very little from each other in regard both to consumption and candle-power, which may be attributed to their careful manufacture. At 110 volts they behaved, from the point of view of life, slightly worse than at 102 volts. The curves of one of the 102-volt lamps are given in Fig. 2.

Table III.—*Lamps 16 c.p., 102 volts, "Gabriel." (Brass and vitrite base. Looped filament.)*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candle.
10	0	18·00	0·63	3·57
10	250	16·54	0·62	3·81
10	500	16·00	0·62	3·95
9	750	15·40	0·61	4·04
9	1,000	14·98	0·61	4·16
		110-volt Test.		
10	0	25·27	0·66	2·88
9	250	24·34	0·66	3·00
9	500	21·00	0·65	3·40
9	750	18·00	0·65	3·00
9	1,000	15·00	0·63	4·62

At 102 volts one lamp was destroyed after 650 hours, two lamps after 1,500 hours, seven lamps lasted more than 2,000 hours. The average life of the "Gabriel" lamps was 1,800 hours, they consumed 63 watts each, with an average candle-power of from 15½ to 16 candles. The curves relating to one of these lamps is given in Fig. 3. The 10 c.p. 102-volt lamps of the same make took 41 watts, lasted 1,500 hours, and gave a mean of 9·5 candles.

Table IV.—*Lamps, 16 c.p., 103 volts, made by the French Edison-Swan Company. (Screw base.)*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candle.
10	0	18	0·660	3·74
10	250	16	0·660	4·21
10	500	15	0·660	4·50
10	750	14	0·659	4·80
9	1,000	13	0·650	5·10
		110-volt Test.		
10	0	21	0·70	3·70
10	250	20	0·69	3·79
9	500	18	0·69	4·22
9	750	14	0·68	5·34
9	1,000	13	0·68	5·75

At 102 volts the lamps gave out as follows :—

1 lamp after 800 hours. 2 lamp after 1,700 hours.
3 ,, ,, 1,200 ,, 3 ,, at about 2,000 ,,
1 ,, ,, 1,500 ,,

The average life was 1,500 hours, the energy consumed 67 watts, and the candle-power 15. In Fig. 4 the mean curves of these lamps are given.

Table V.—*Lamps 16 c.p. English Edison-Swan. (Swan base.)*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts.
10	0	18·4	0·590	3·27
10	250	17·5	0·590	3·43
9	500	16·0	0·585	3·73
8	750	14·6	0·580	4·05
8	1,000	13·9	0·580	4·40
		110-volt Test.		
10	0	20·0	0·61	3·35
8	250	18·2	0·61	3·68
8	500	16·3	0·61	4·11
7	750	15·0	0·60	4·40
7	1,000	14·4	0·60	4·58

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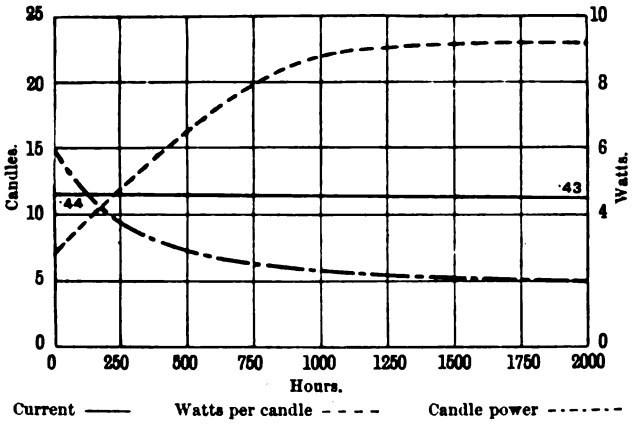

FIG. 1.—Lamp 16 c.p., 102 volts, made by the Compagnie "La Française."

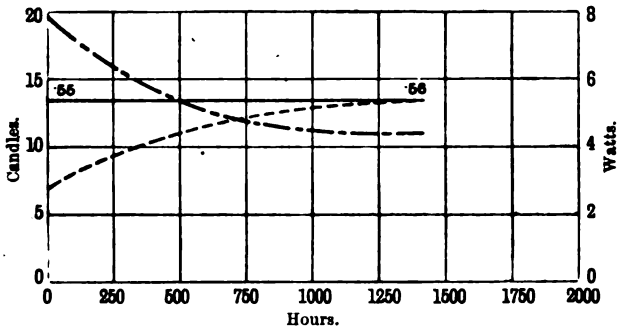

FIG. 2.—Lamp 16 c.p., 102 volts. Siemens.

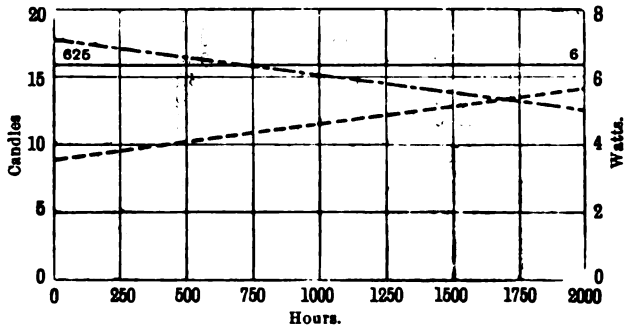

FIG. 3.—Lamp 16 c.p., 102 vo Gabriel."

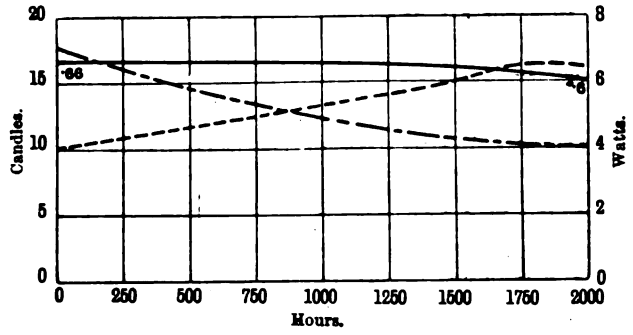

FIG. 4.—Lamp 16 c.p., 103 volts. Made by the French Edison-Swan Company.

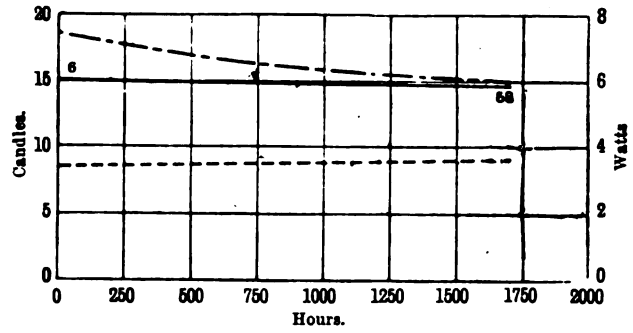

FIG. 5.—Lamp 16 c.p. Made by the English Edison-Swan Company.

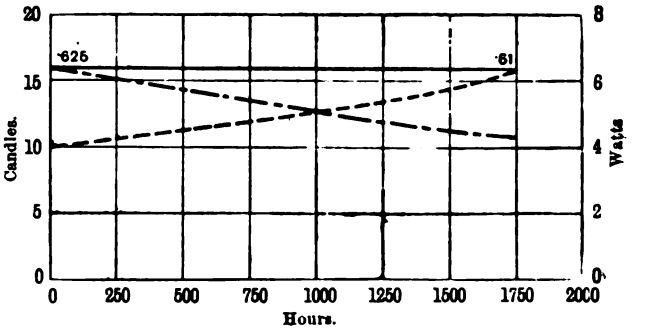

FIG. 6.—Lamp 16 c.p., 100 volts. Khotinsky.

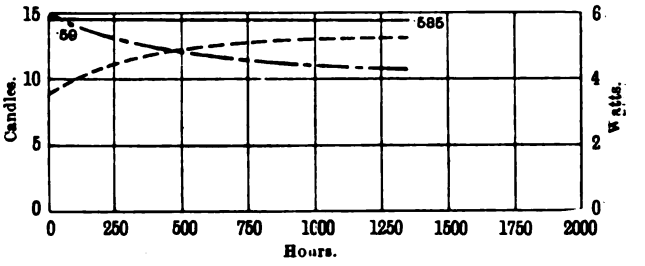

FIG. 7.—Lamp 16 c.p. "Cruto."

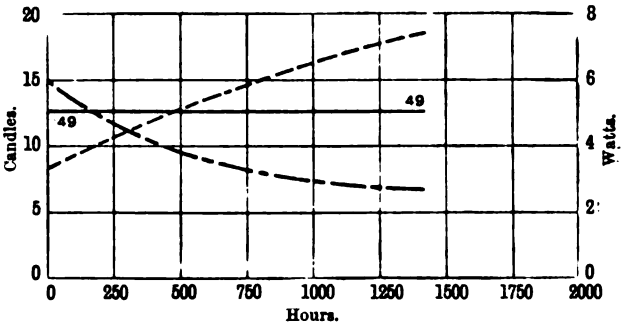

FIG. 8.—Lamp 16 c.p., 102 volts. Made by the Allgemeine Elektricitäts-Gesellschaft.

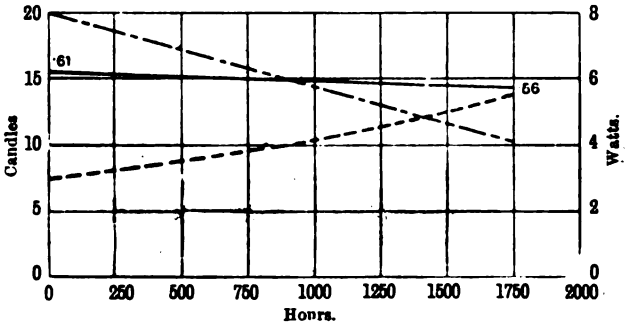

FIG. 9.—Lamp 16 c.p., 100 volts. Société Hongroise.

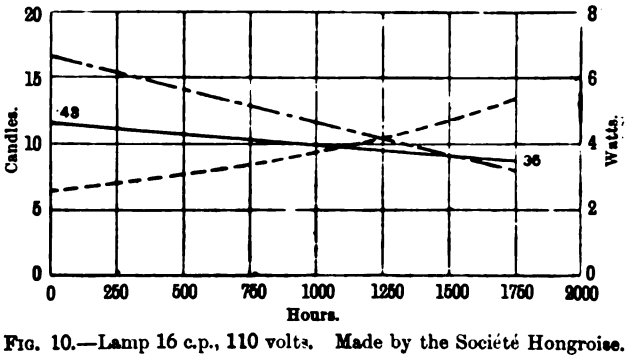

FIG. 10.—Lamp 16 c.p., 110 volts. Made by the Société Hongroise.

At 102 volts 1 lamp gave out after..... 400 hours.
1 ,, ,, ,,..... 650 ,,
7 ,, lasted more than ..... 1,500 ,,

The average life may therefore be taken at 1,200 hours, the average energy consumed at 60 watts and the average candle-power at 16 candles. The curves of one of these lamps are shown in Fig. 5

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Table VI—*Lamps 16 c.p., 100 volts. Khotinsky.*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candle.
10	0	16·5	0·630	3·90
10	250	15·8	0·625	4·30
9	500	14·7	0·620	4·31
8	750	13·3	0·618	4·70
8	1,000	13·0	0·618	4·84

110-volt Test.

10	0	20·3	0·66	3·58
10	250	18·4	0·66	3·94
9	500	17·5	0·65	4·09
8	750	15·3	0·65	4·67
8	1,000	14·6	0·65	4·95

In the 102-volt test one lamp gave out, after 300 hours; eight lasted more than 1,200 hours; one more than 2,000 hours The average life was 1,300 hours, the energy consumed 63·25 watts, and the candle-power 14 candles. The curves of one of these lamps is given in Fig. 6.

Table VII.—*Lamp 16 c.p. Standardised. "Cruto."*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candle.
10	0	16·4	0·590	3·67
10	250	14·0	0·585	4·26
10	500	12·8	0·585	4·68
9	750	11·2	0·585	5·32
8	1,000	11·0	0·585	5·42

110-volt Test.

10	0	20·3	0·610	3·30
9	250	17·4	0·610	3·85
9	500	16·1	0·609	4·15
8	750	15·1	0·605	4·40
7	1,000	13·3	0·605	5·00

1 lamp gave out after ..... 700 hours.
1 ,, ,, ,, ... 900 ,,
4 ,, ,, ,, ...1,200 ,,
5 ,, at about .....1,300 ,,

The average life was therefore 1,100 hours, the consumption about 60 watts, and the candle-power 13 candles. The curves of one of these lamps are given in Fig. 7.

Table VIII.—*Lamps 16 c.p. 102-volts, made by the Allgemeine Elektricitäts Gesellschaft. (Brass and plaster base. Looped filament.)*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candles.
10	0	15·0	0·490	3·33
10	250	13·3	0·485	3·64
9	500	11·0	0·485	4·48
9	750	9·7	0·485	5·10
8	1,000	8·8	0·485	5·61

110-volt Test.

10	0	16·3	0·52	3·51
8	250	14·8	0.52	3·93
6	500	13·2	0·50	4·13
6	750	8·3	0·50	6·06
4	1,000	6·4	0·49	8·42

1 lamp gave out after..... 300 hours.
1 ,, ,, ,, ... 800 ,,
6 ,, ,, ,, ... 1,300 ,,
2 ,, ,, ,, ... 1,500 ,,

These lamps lasted on an average 1,000 hours, they consumed about 60 watts and gave a mean light of 12 candles. They are intended to be replaced after 400 hours' use. The curves of one of these lamps are given in Fig. 8. The 10 p.c. 103-volt lamps of the same makers gave at 102 volts an average light of 8·5 candles, consumed 34·7 watts, and lasted approximately 1,300 hours.

Table IX.—*Lamps 16 c.p., 100 volts. Société Hongroise. (Vitrite base. Looped filament.)*

102-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candle.
10	0	20·95	0·62	3·00
10	250	17·00	0·61	3·78
10	500	16·34	0·61	3·87
9	760	15·41	0·60	4·00
9	1,000	13·23	0·58	4·45

110-volt Test.

10	0	35·00	0·68	2·13
10	250	24·30	0·67	3·40
8	500	17·34	0·66	4·20
8	750	16·00	0·66	4·53
7	1,000	15·30	0·66	4·75

One lamp gave out after 600 hours, eight after 1,300 hours, one after 1,600 hours. The life of these lamps is almost 1,250 hours, they consume 62 watts, and have an average candle-power of 16 candles. It is to be remarked that the maximum candle-power is not reached until after 75 to 100 hours, and that these lamps heat considerably. The curves of one of the lamps are given in Fig. 9.

Table X.—*Lamps 16 c.p., 110 volts, made by the Société de Zürich. (Screw base.)*

110-volt Test.

No. of lamps under test.	Hours.	Candle-power.	Amperes.	Watts per candle.
10	0	17·62	0·438	2·73
8	250	16·65	0·416	2·75
6	500	11·00	0·375	3·79
4	750	10·11	0·381	4·19
2	1,000	7·35	0·340	5·15

Average consumption, 45 watts; life, 600 hours; candle-power, 16 candles. Of the lamps which lasted more than 1,000 hours, one had lost 60 per cent. more of its candle-power than the other, which caused the high figure in the fifth column. The curves in Fig. 10 relate to one of these lamps. The 10 c.p. 110-volt lamps of the same firm had an average life of 300 hours, consumed 33 watts, and gave 10 candles.

Some 10 c.p. 110-volt lamps, called "lampes rationnelles Gérard," had an average life of 500 hours, consumed 34 watts, and gave a light of 13 candles.

Table XI.—*General Results of 102-Volt Test for 1,000 Hours.*

Make of lamp.	Candle-power. Nominal.	Maxima at the commencement.	Minima after 1,000 hours.	Average.	Watts per lamp.	Average life.
La Française	16	15·02	5·08	8·50	44·80	1,400
—	10	10·47	5·21	8·00	36·00	1,000
Siemens	16	19·80	11·30	14·00	61·00	600
Gabriel	16	18·00	14·98	16·00	63·00	1,800
—	10	13·55	8 56	9·50	41·00	1,500
Edison-Swan (French).	16	18·00	13 00	15·00	67 00	1,500
Edison-Swan (English)	16	18·40	13·90	16 00	60·00	1,200
Khotinsky	16	16 50	13·00	14·00	63·25	1,300
Cruto	16	16·40	11·00	13·00	60 00	1,100
Allg. Elect. Gesell.....	16	15·00	8·80	12·00	50 00	1,000
—	10	10·00	5·08	8·50	34·70	1,200
Société Hongroise	16	21·00	13·25	16·00	62·00	1,250
Société de Zürich	16	17·62	7·35	12·00	45·00	600
—	10	12·92	9 70	10·00	33·00	300
Gérard.....	10	13 80	11·00	13·00	34·00	500

In the latter makes of lamp tested it will be seen from the table that some with a mean illuminating power of 12 to 13 candles (16 nominal) did not take more than 45 watts, and lasted 600 hours. The 10 c.p. Gérard lamps could, if need be, be used in place of 16 c.p. lamps, since they take on the average 50 per cent. less power than old 16 c.p. lamps, the average candle-power of which is not better than that of the 10 c.p. lamps.

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THE CONDENSATION OF STEAM.*

It is known that in all steam engines liquefaction takes place in the cylinder, and this is invariably explained on the assumption that the metal being cooler than the steam with which it comes in contact, a transfer of heat takes place from the steam to the iron, condensation ensuing as a natural consequence. No doubt this is the truth, but is it the entire truth? Is this explanation consistent with facts and phenomena taken as a whole? Is the hypothesis competent to explain everything connected with liquefaction in steam cylinders? There is reason to think that the reply must be in the negative; and if so, then we are presented with a very interesting region for physical research; one that can be better explored, moreover, by the physicist than by the engineer, because it is easier to carry out the requisite experiments with the great accuracy required in the laboratory than in the engine room. Our object now is to state the case for inquiry; not to dogmatise, but to suggest.

It was at one time held that cylinder condensation largely depended for its amount on the range of temperature in the cylinder. We have heard it stated, for example, that if the range of temperature in a cylinder were, say, 100deg. and the condensation x lb. per hour, then, all the other conditions remaining unaltered, if the range of temperature were doubled the condensation would become $2x$ lb. per hour; and engineers holding this view very naturally said that the compound and triple-expansion engines were more economical than simple engines, mainly because the range of temperature in each cylinder of the multi-cylinder engine was reduced, as compared with the range in the single cylinder. Reasoning of this kind is seldom or never heard now; because it is well known that cylinder condensation is greater in the triple than any other form of expansion engine, unless it be the quadruple engine. In a word, facts all go to show that cylinder condensation is largely independent of range of temperature. But if this is really, as it is apparently true, then it seems to be clear that we must seek for some other cause of liquefaction. Furthermore, the amount of liquefaction shows itself to be royally independent, bearing no fixed relation to any condition. Thus in two engines practically identical, and working under similar circumstances, we shall find one condensing far more steam than the other.

The whole theory of liquefaction, as commonly stated, is that it can only be brought about by the steam coming into contact with something colder than itself. This assumption is taken for granted; it is held to be capable of convincing proof that so long as steam is kept in a vessel, the walls of which are at its own temperature, no condensation can take place. We are quite willing to grant this, but with a limitation; that is to say, it is quite true of steam kept at rest. The point in doubt is whether it is or is not true of steam in motion. A recent experience—not an experiment—throws some light on this question. Drains fitted to certain steam pipes, all supplied by the same battery of boilers, showed that small steam pipes invariably supplied wetter steam than larger pipes. The steam pipes were all carefully clothed, clothed, indeed, to a quite unusual degree, and the loss by radiation must have been very small; but small or great, there was the water. It is very difficult to believe that in this case—concerning which we may have more to say at another time—the temperature of the metal of the steam pipe could have had much to do with the amount of condensation. Let us consider for a moment what is the nature of the fluid—steam—with which we are dealing. It is of all others perhaps the most unstable that it is possible to produce. A touch with a feather is sufficient to upset the balance in the solid iodide of nitrogen, and an explosion ensues. A touch with a drop of cold water suffices to upset the equilibrium of steam, and the water molecules fall together like a flash. Again, we know that if a permanent gas expands doing work the while, its sensible temperature falls; but when steam expanding does work a portion of it is liquefied. Here there is no question of transfer of heat from a hotter to a colder body. Again, we can go on compressing gas within comparatively enormously wide limits without producing liquefaction; but in the case of steam, if there be water present in sufficient quantity—somewhere about 30 per cent. will suffice—after a certain degree of compression has been reached, no further rise in pressure can be obtained. The steam proceeds to liquefy. The action is as though the water present absorbed it like a sponge. Here, again, we have liquefaction without transfer of heat from a hotter to a colder body. Thus, then, it will be seen that steam will liquefy whether it is doing or has work done upon it; and the action is often apparent in actual indicator diagrams, liquefaction taking place because of the presence of water during the compression period. But this is not all. The presence of some solid body appears to be essential to liquefaction. It has been shown by Mr. John Aitken that if air—that is space, for the air plays a secondary part—saturated with moisture be cooled, the moisture will not deposit unless there are dust particles present on which condensation can take place. During the delivery of a very interesting lecture on liquids and gases delivered by Professor W. Ramsay, on May 8th, 1891, at the Royal Institution, he showed an experiment to illustrate Mr. Aitken's statement of fact. "If," said the lecturer, "air be suddenly expanded it will do work against atmospheric pressure, and will cool itself. This globe contains air, but the air has been filtered carefully through cotton-wool, with the object of excluding dust particles. It is saturated with moisture. On taking a stroke of the pump, so as to exhaust the air in the globe, no change is evident; no condensation has occurred, although the air has been so cooled that the moisture should condense, were it possible. On repeating the operation with the same globe after admitting dusty air—ordinary air from the room—a slight fog is produced, and owing to the light behind, a circular rainbow is seen; a slight shower of rain has taken place. There are comparatively few dust particles, because only a little dusty air has been admitted. On again repeating, the fog is denser; there are more particles on which moisture may condense." This is a highly-suggestive experiment, if regarded in a proper spirit. The difference between vapour suspended in the atmosphere and steam of any pressure is little more than one of degree. If vapour, although cooled, will not condense unless dust particles are present, it is fair to assume, first, that steam would not condense; and, secondly, we may proceed to ask, What effect a difference in the size of the dust particles and in their material would produce on the phenomena?

We believe that in the face of all the facts we have briefly placed before our readers, it is impossible to maintain that steam can only be liquefied by the direct abstraction of heat. We may now proceed a step further, and consider what may happen when steam is in rapid motion round turns and bends. Let us take it for granted, for example, that steam, rushing into a cylinder through crooked ports, comes into contact with metal just of the same temperature as itself, and the conditions are such that this metal can never get hotter than the steam. We have seen that the fluid with which we have to do is in a state of unstable equilibrium. The water molecules are only kept apart by the energy which has been imparted to them by the heat called "latent," but which is really no longer heat. If, now, something occurs to initiate liquefaction, there is no reason why it should not proceed until at least the metallic surface becomes covered with moisture, and the steam is no longer in contact with it. What, it may be asked, can initiate liquefaction under such conditions? The answer can be only tentatively suggestive. The thermo-dynamic theory of gases is supposed to apply to steam. According to it, the molecules are in rapid motion, bombarding the surfaces of the containing envelope, from which they recoil without loss of energy; but this recoil without loss of energy can only hold true of molecules which are perfectly elastic. Let it be granted for argument's sake that the molecules in the steam are imperfectly elastic. So long as the steam is not in motion—and the motion of a current of steam must not be confounded with its intra-molecular motion—the difference in elasticity between steam and a perfect gas is too small to produce an appreciable effect. Let us suppose now that we have an india-rubber ball, which, when dropped on the floor, will always return to the hand so long as it is only thrown down with a certain force, but let the force be augmented sufficiently to injure the ball and it can no longer return. Or to take another case, a steel shot is driven against an armour plate which it is unable to penetrate with a given charge of powder, and it rebounds uninjured from the plate. The charge of powder is increased and the shot breaks up. Now it is evident that the molecules of steam which first rush into a cylinder when the port is opened, are driven clear across to the other side, and violently impelled against the metal; and knowing how fine is the distinction between steam and water, how nice the balance of forces, is it too much to say that the imperfectly elastic molecules will not rebound, but will part with some of their energy to the metal, and falling together will assume the condition of water. All this is pure hypothesis. But it is hypothesis which is consistent with existing theories and existing experiments. Let us, on the other hand, reject the idea that the knocking of steam about, its collision with cylinder walls, the bends in steam pipes, and such like, can have any effect; let us take it for granted that it is impossible, do what we may with steam, to condense it so long as it is in contact with a surface possessing the same sensible temperature. How are we, then, to reconcile this proposition with the facts which we meet with at every turn—the enormous amount of condensation which takes place in the well-jacketed high-pressure cylinder of a triple-expansion engine; the increase in condensation due to the use of small or crooked steam pipes, as compared with those that are larger or straighter; or the circumstance that steam separators, which depend for their operation on the "knocking" of the water out of the steam, often prove failures, taking out a good deal of water, and yet leaving the steam nearly as wet as they received it?

It is, we think, time that the questions we have raised were fairly and dispassionately examined. Either it is or is not true

* From *The Engineer*.

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that other influences than mere difference of temperature can cause steam to part with its heat. It would not involve the expenditure of very much time, trouble, or money to carry out at least a preliminary trial, which would throw a good deal of light on the points at issue. Thus, for example, a length of 100ft. of straight steam pipe might be fitted up, steam at a given pressure allowed to flow through it, and the amount of condensation measured by collecting, at the end furthest from the boiler, the water deposited. A similar experiment might then be made with a tube of the same length and dimensions, but put together with numerous sharp bends. Different experiments of this kind will suggest themselves. It has long been known to engineers that steam engines with short straight ports are better than engines with crooked and long steam passages. It would be instructive to ascertain to what the economy of the former is due. Is the cylinder condensation less in one case than the other? Finally, we would repeat what we said at the outset, namely, that we do not pretend to dogmatise; all that we have attempted is to show that there is a good case for further inquiry concerning the phenomena of condensation. The subject should be approached with an open mind, and the inquirer should not let himself be persuaded that everything is already known about steam that can be known.

THE FUTURE OHM.*

BY CH. ED. GUILLEAUME.

My readers know that the English propose to abandon the time-honoured British Association unit, and, neglecting the *legal* ohm, to adopt the 106·3 ohm. I propose to-day to inquire into the reason of this reform and to point out its practical bearing.

As early as 1884 several electricians, amongst others Lord Rayleigh and M. Mascart, demanded the adoption of the 106·3 ohm, but the few very low values obtained by well-known physicists caused the mean determination 106 to be adopted, a result which satisfied no one, everyone maintaining the correctness of his own figure. Prof. Rowland, whose determination carried out with great care was yet another argument in support of 106·3, proposed in a circular to reconsider the decisions of the Congress. But people were weary of the discussion and the reform was deemed premature. Moreover, Prof. Rowland's argument seemed absolutely convincing, attributing as he did the coefficient 6 to the high values and coefficients down to as little as 0 to the low values, he could not help finding as his mean the number which he proposed as the result of his calculations.

However, fresh determinations before long proved decisive arguments in the debate. Kohlrausch and Dorn, who had found respectively the values 105·51 and 105·46, passed over to the opposite camp with the numbers 106·30 and 106·24. Wild's determination, when corrected for a fault in his resistance box, rose from 105·68 to 106·18; the lowest numbers as to which there was still some slight uncertainty. Finally, an excellent determination of M. Wuilleumier gave the figure 106·27. This gentleman had employed the formula of MM. Mascart, de Nerville and Benoît for reducing to 0° the mercury unit which he made use of. The determination which I have recently made† of the variation of the resistance of mercury slightly raises this number and brings it up to 106·29. It is unnecessary to discuss these results, suffice it to say that the mean of the determinations worthy of being taken into account is almost exactly 106·3, with individual deviations which do not amount to half unity from the fourth figure. The exact mean seems accurate to within less than two units of the fifth figure. In other words it is very probable that the true ohm is to be found between 106·28 and 106·32, and we cannot reasonably expect to see this more precisely known except after many years. Thus the first point gained is that in adopting the 106·3 ohm we shall no longer work under an uncertainty; the commercial ohm will have what will long remain the most probable value of the true ohm.

It may be objected that the partial adoption of a new ohm will not suppress any of the old ones and will only increase the confusion. An investigation of the facts leads to the opposite conclusion. The *legal* ohm, as I have remarked above, satisfied nobody, and the dissatisfaction was shown by matters being left in *statu quo*. Germany is to-day still using the Siemens unit, England has kept to the B.A. unit, which it is now about to definitely abandon, and France, the most promising country for the reformers, is divided between the *legal* ohm and the B.A. unit. Germany now seems very disposed to adopt the proposals of the British Association, though I am given to understand that this decision was not arrived at without a lively discussion between Prof. von Helmholtz and Dr. von Siemens; nevertheless, the step is taken. The value definitely adopted, acceding as it does to the wishes of French physicists, cannot but be well received in this country, especially as it will put an end to a difference existing between the various State departments. In any case, the Siemens unit and the B. A. unit have had their day, and the new ohm may be considered identical with the true ohm. The only competitor would be the *legal* ohm of 1884, and if this is abandoned, as I hope it will be, the system will be unified. It is, moreover, probable that the resistance boxes have gone ahead of this step, and that coils constructed a few years ago and adjusted to the *legal* ohm have reached, if not passed, the true ohm.

The definition proposed by the British Association may seem uncouth. It would seem, in fact, as if the adoption of an experimental length (106·3) could only be assigned by the *à priori* definition of a cross-section expressed by a whole number, such as the square millimetre. Yet now we have this factor expressed by six significant figures (14·4521 grammes of mercury in the tube). This last definition has only been given for the metrologists. In reality the square millimetre remains the elementary definition, but with the specification that this is arrived at by mercurial weighings, taking unity as the value of the density of water, and 13·5956 as that of mercury. The metrologic definition would have been quite as accurate, and certainly more comprehensible, if, instead of indicating the total mass of mercury contained in a tube 106·3cms. long, the mercury column had been defined as weighing 13·5956 grammes per metre. Let me remark that Barus has shown that the specific resistance of mercury diminishes by 0·00003 of its value when the pressure to which it is submitted is increased by one atmosphere. It would be proper, therefore, to add the following words to the original definition, "under normal atmospheric pressure," which would also be for the use of metrologists only.

With the adoption of an international ohm, one of those differences so prejudicial to progress will cease; prejudicial, because they cause time to be lost in a fastidiously refined work of determination which might be employed on true scientific work. The unification of measures has made such a prodigious stride during the last twenty or thirty years that we may hope in a few years to understand one another's writings without having to make constant use of a conversion table.

* From *l'Industrie Électrique*. † See last week's *Electrician*, p. 553.

INFLUENCE OF THE ELECTRIC LIGHT ON THE STRUCTURES OF TREES, WHEN CONTINUOUSLY AND INTERMITTENTLY APPLIED.*

BY GASTON BONNIER.

Previous attempts at cultivation by aid of the electric light have had more especially for their object the general development of the plants. In my own investigations I have sought to discover what modifications of anatomical structure it was possible to obtain by submitting plants to a light of sensibly constant intensity. Two similar groups of plants were submitted, one to a sensibly constant electric light, the other to the same light from 6 a.m. to 6 p.m., and to darkness between times. A third group placed in open air under normal conditions was used as a means of comparison. The experiments were carried out in the electric lighting station at the Halles Centrales (Paris), where the plants were in a sensibly constant temperature of about 13° to 15° C. (55° F. to 59° F.) and where the air was renewed somewhat slowly. The light was obtained from globe-covered arc lamps and the plants were under glass. The surroundings did not permit of the cultivation of any kind of plant. Austrian and Scotch pines, oak, beech, and birch were experimented on.

The outcome of these experiments goes to show that the electric light continuously applied does not merely retard the formation of the vegetable tissues, but gives rise to considerable modifications of structure in the leaves and shoots of young trees. If a plant respires, assimilates and transpires in an unvarying manner during the whole of the twenty-four hours it seems as if it were troubled by this state of things, and its tissues have in consequence a more simple structure. On the other hand, when the electric light is cut off for twelve hours a day the organic structure more closely approximates the normal.

* Abstract of a Paper read before the Académie des Sciences, September 19th. *Comptes Rendus*, Vol. CXV., No. 12, p. 447.

ELECTRIC LIGHTING PROVISIONAL ORDERS.

In a report dated June 23rd, but only just published, the Permanent Secretary to the Board of Trade states that during the year 1891-92 32 electric lighting orders were applied for. Of these applications 17 originated from Local Authorities and 14 from companies, and 1 from a firm of electrical engineers; 11 related to the metropolis. Last year the total number of applications was 70, of which 37 were made by Local Authorities and 33 by companies, 12 applications relating to London.

As will be seen by the table below, 24 orders in all were granted, and all the Bills confirming these grants subsequently received the Royal Assent. Of the 25 Orders granted, 17 were granted to Local Authorities and 7 to companies.

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C. = Company. L.A. = Local Authority.

Order.	How dealt with.
	METROPOLIS.
County of London, N. (C.)	Granted in part (County of London Electric Lighting Company).
County of London, S. (C.)	Granted in part (County of London Electric Lighting Company).
East London—Hackney (C.)	The Board of Trade declined to grant the Order, as the promoters (East London Electric Supply Company) failed to satisfy them that they were in a position to discharge the duties and obligations that would be imposed upon them by the Order, if granted.
Hampstead (L.A.)	Granted.
Lambeth (L.A.)	Granted.
North London (C.).	The Order was granted on the understanding that before the introduction of the Confirming Bill the Promoters (Camberwell and Islington Electric Light and Power Supply) should satisfy the Board of Trade that they were in a position to discharge the duties and obligations that would be imposed upon them. They, however, failed to do so, and the Bill was not introduced.
St. Mary (Islington) (C.)	The Promoters (Messrs. Sharp and Kent) failed to produce the consent of the Local Authority or to satisfy the Board of Trade that it should be dispensed with, and the Board of Trade refused to grant the Order.
Shoreditch (L.A.)	Granted.
South London (C.)	The Order was granted on the understanding that before the introduction of the Confirming Bill the Promoters (Camberwell and Islington Electric Light and Power Supply) should satisfy the Board of Trade that they were in a position to discharge the duties and obligations that would be imposed upon them. They, however, failed to do so, and the Bill was not introduced.
West London (C.)	The Board of Trade declined to grant the Order, as the promoters (Putney and Hammersmith Electric Light and Power Supply) failed to satisfy them that they were in a position to discharge the duties and obligations that would be imposed upon them by the Order, if granted.
Whitechapel (L.A.)	Granted.
	PROVINCES.
Aberystwith (L.A.)	Granted.
Ashton-under-Lyne (L.A.).	Granted.
Brighton (C.) ...	The Promoters (The Brighton and Hove Electric Light Company) failed to produce the consent of the Local Authority or to satisfy the Board of Trade that it should be dispensed with, and the Board of Trade refused to grant the Order.
Dublin (L.A). ..	Granted.
Fareham (C.) ...	Granted.
Govan (L.A.) ...	Granted.
Halifax (L.A.)...	Granted.
Harwich (L.A.)	Granted.
Kilkenny (L.A.)	Granted.
Limerick (L.A.)	Granted.
Liverpool (C.)...	Granted.
Maidstone (L.A.)	Granted.
Newbury (L.A.)	Granted.
Oxford (C.) ...	Granted.
Sheffield (C.) ...	Granted.
Sutton (Surrey) (L.A.)	Granted.
Walton-on-Thames (C.)	The Board of Trade declined to grant the Order, as the Promoters (Weybridge Electric Supply Company) failed to satisfy them that they were in a position to discharge the duties and obligations that would be imposed upon them by the Order, if granted
Waterford (L.A.)	Granted.
Waterford (C.)	Refused. (City of Waterford Electric Supply Company.)
West Ham (L.A.)	Granted.
Woking (C.) ...	Granted.

The following applications for licences have been received since the date of the last report, and are at present under consideration:—The Ogmore Valley Electric Light and Power Supply Company (a portion of the district of the Ogmore and Garw Local Board); the Shropshire Electric Light and Power Company (a portion of the borough of Shrewsbury); the Isle of Wight Electric Lighting Company (the Urban Sanitary District of West Cowes).

Appended to the report is a list of the Provisional Orders confirmed by Parliament (prior to the 1891-92 Session) and of the licences granted by the Board of Trade, since the passing of the Electric Lighting Act, 1882, showing those which have since been revoked or repealed. From this list it appears that, including the Provisional Orders contained in the above table, no less than 116 Local Authorities and 60 Companies possess electric lighting powers.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 17, 1892.

The Western Union Company.—The Western Union Telegraph Company has decided to increase its capital stock to $100,000,000. The present capitalisation of the Company being $86,200,000, this proposed increase of $13,800,000, it is said, represents money expended for extensions and improvements.

Electrically Propelled Vehicles in Chicago.—Considerable interest is manifested in Chicago in the subject of electrically propelled vehicles in view of the fact that the possible field of usefulness of such vehicles at the time of the World's Fair may be large. An electric carriage, under the control of Mr. J. B. McDonald, president of the American Battery Company of Chicago, was operated last week on the streets of that city, and from the reports made the working of the vehicle seems to have been a success. The total number of cells carried on the vehicle is 24. Each of these cells is of 150 ampere hours' capacity, with a total available E.M.F. of 48 volts. The cells are arranged in sets of eight each, one set being placed under each of the three seats of the carriage. The motor used is rated at 2½ H.P., is series wound, and is connected to the rear axle of the carriage through a train of ordinary gearing. The rear carriage wheel is four feet in diameter, and may be driven at a speed corresponding to six or seven miles per hour. The controlling apparatus, which consists of a contact bar and a reversing switch, is attached to the under side of the carriage floor. The steering apparatus is of peculiar construction; each of the two front wheels bears upon a swivelled bearing, so as to swing horizontally and independently of the axle, which is rigidly fixed in a position parallel to the rear axle. A yoke bar connects the two front wheels, and to this bar is connected the gear wheel upon the steering lever, which permits of the two wheels being swung to the right or left as desired. Some recent tests with this carriage, made by Mr. Pumpelly, show that the average current called for when carrying a load of six people varies from 25 to 35 amperes under ordinary running, and rises as high as 50 amperes when starting from a full stop.

The Proposed Chicago-St. Louis Electric Railway.—Work was commenced last week on a section of the proposed Chicago and St. Louis Electric Railway, and the construction will be pushed forward as rapidly as possible. A good deal of doubt has been expressed as to the genuineness of the intentions of the Company promoting this scheme, but, notwithstanding a good deal of opposition from the technical press, the scheme seems to be well founded and to have excellent backing. Dr. Wellington Adams, it is announced, will make a trip to Europe in a week or two in connection with the car equipment, which will probably be manufactured abroad where considerable experience has already been had with multiphase motors.

CORRESPONDENCE.

NAVAL SIGNALLING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have noticed a letter from Mr. Kelway in your issue of the 23rd inst. in which, if he will pardon me saying so, I think he has totally mistaken the signalling requirements of the Navy. It is of very little importance to the Navy at large that signals may be read by every casual observer; in fact, in many cases such a thing may be highly objectionable. It is impossible except at great length to lay down exactly what system we require, since signalling at night may take either the form of a lengthy communication or of an executive signal which may require instant recognition and immediate action. The most untechnical person can easily see the vast difference between the *desiderata* of the two.

In the Navy the system we try to get is "the best to suit our requirements," and although I am perfectly aware of the

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great disadvantages of our system of flashing lights, still I am equally aware of the enormous disadvantages that many other systems possess, and the numerous difficulties that beset the whole question of which persons unacquainted with our requirements are totally ignorant. Mr. Kelway may rest assured that if he has presented his system of signalling to the Admiralty it will receive their full consideration, and if there is in their opinion the slightest chance of its ultimate success it will be handed over for trial to men of considerable experience and thoroughly qualified to judge of its capability. One word more. I know there is a prevalent opinion that we naval officers are behind the times, and ultra-conservative as regards improvements, but such judgments I venture to think are hastily arrived at. We possess considerable practical knowledge of life and the conditions that surround life at sea, experience that rarely falls to shoregoing people, and at the same time we have to arrange all our appliances for war time as well as for peace, and if to this we add the fact that adoption of instruments, machines or systems of communication affect several hundred ships, I think we may well be excused if we act with deliberation, and are not carried away like the Athenian of old "by every new thing."—Yours, &c.,

R. H. Bacon, Lieut. R.N.

H. M. S. "Vernon."

EARTH CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to your article on Earth Currents in issue of August 5th, the following may be of interest:—On July 12th from 5:30 to 7:30 p.m. (Greenwich time) we had very strong E.C.'s on north and south of here, and again on 16th from 10:30 a.m. to 9 p.m. (Greenwich time) E.C.'s were excessively strong, and caused great difficulty in working at times. The same trouble was experienced south.—Yours, &c.,

William H. Mardock.

The Western and Brazilian Telegraph Company,
Ceara Station, August 29, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Tenders Invited.—The Dundee Gas Commissioners invite tenders for the supply and erection of two overhead travelling cranes for the electric lighting station. Particulars can be had from Mr. T. Thornton, clerk to the Commissioners, to whom tenders must be delivered on or before October 10th. Further particulars are given in our advertisement columns.

——— The Glasgow Police Commissioners invite offers to renew and maintain the Street Fire Alarm and Telegraph Lines belonging to the Fire Department. Tenders must be in by 10 a m. on 7th prox.

——— The Derby Corporation are prepared to receive tenders for the builders' work in the engine and boiler house, &c., and accessories, at the Central Station. Tenders must be in by 12 on 10th prox.

——— The Town Council of Windsor invite tenders for the supply of gas or other illuminant for the public lamps, for one year. Tenders to be in by the 8th prox.

Tenders Accepted.—Mr. T. Barton, of Blackburn, has received the contract for supplying and fixing electric light fittings for the new police-courts at Nelson.

Appointment Vacant.—The Electric Light Committee of the Dublin Town Council require a clerk and storekeeper not more than 30 years old, at a salary of 30s. per week. A knowledge of electricity is desirable. Particulars of Mr. Beveridge, town clerk, Dublin, to whom applications must be sent by 5 p.m. on October 3rd.

Edison General Electric Company.—We understand that this Company is about to be reorganised, and that it is intended to close the London office.

Bankruptcy.—*In re James Collins.*—An inquiry into the circumstances attending the failure of this bankrupt took place at Brighton last week, the result being that the debtor passed his examination.

In Liquidation.—The New British Iron Company, one of the leading Staffordshire marked bar iron houses, has gone into voluntary liquidation. The Company is a very old-established one, and is the owner of the well-known Corngreaves Ironworks.

General Electric Power and Traction Company (Limited).—Messrs. Harpers (Limited), of Aberdeen, have placed an order for the electric lighting of their very extensive new workshops with the above firm.

Personal.—Mr. Albion T. Snell is practising as a consulting engineer, making a specialty of electrical transmission of power, more particularly with reference to colliery and mining work, and is working in conjunction with Messrs. Walker and Hardwick, of Sheffield and London. Mr. Snell's offices are at Suffolk House, Laurence Pountney-hill, E.C., and North Church-street, Sheffield.

Messrs. Mavor and Coulson.—This firm have completed the installation of the electric light at Ardrossan Harbour.

Messrs. Evered and Co. (Limited).—This firm will shortly issue their new catalogue, which will contain a number of new designs in electric light and combination fittings. A large assortment of pillar lamps has been added to the former lists, many of these being marked at prices much below previous quotations. A feature of the list is the new six-light billiard-table group (E482) marked at £9. 9s., and several examples of dining-room suspender lamps, which are made to take any kind of silk shade. Numbers E852 and E853 in the list are particularly good examples of these dining-room lamps, which are stocked in triple lights, and are made to order for any number of lamps. Novelties are also shown in vestibule lights, and some choice specimens of wrought-iron work will be found included. Illustrations E974 and E975 show a new method of sliding arrangement for pedestal lights, by which the flexible wire is fed through the centre of the pedestal, instead of entering at the top or being attached from the outside. Messrs. Evered and Co. have a patent switch, which they make in all sizes, an advantage claimed being their high insulation. The new catalogue also contains illustrated particulars of a variety of electrical accessories manufactured by the firm.

Messrs. Drake and Gorham.—Amongst the contracts recently obtained by this firm for lighting are those for the offices of Messrs. John Dickinson and Co., Old Bailey; the Alliance Assurance Corporation, St. James's-street; Lord Knutsford's London residence in Eaton-square; Mr. James Lowther's residence in Wilton-crescent. Plants are being put down for the Manchester and Liverpool District Banking Company at Manchester, for Mr. C. Swinfen Eady at Weybridge, and a turbine installation at Ewell Court, in addition to extensions to the Inner Temple installation.

Messrs. L. M. Ericsson and Co.—This firm, whose works and offices are situate at Stockholm, Sweden, have just issued the third edition of their illustrated catalogue of telephonic, telegraphic and general electrical apparatus. The book is well arranged and neatly printed in English and German parallel columns throughout. Some admirable illustrations of the various manufactures of the firm are given, the whole occupying 80 quarto pages.

Electric Launches.—Mr. K. Brown, of the Ray Mead Works, Maidenhead, has recently built an electric launch suitable for the Norfolk Broads. This is one of a flotilla of similar boats to be ultimately supplied. The launch batteries are at present charged at the works of Messrs. Laurence, Scott and Co., Limited, but it is anticipated that charging stations will shortly be erected at Oulton, Wroxham, and Yarmouth, in addition to Norwich.

Telephone Extension.—The *Financial News* states that a new Telephone Company is about to be started in Mexico, promoted and managed by Messrs. Ernest and Enrique Ascorve, with a capital of $160,000, in $100 shares.

Exhibition.—It is stated that the electrical section of the exhibition shortly to be held in Rome will be international in character.

Belfast.—At the last meeting of the Lighting Committee of the Corporation it was, we understand, decided to recommend the introduction of the electric light, the idea being to make a commencement with 10,000 lights. This recommendation will doubtless be approved at the meeting on Saturday next. As showing the interest the subject is arousing, a representative of a leading Belfast paper is at present in London collecting material to enable that journal to put before its readers the many advantages of the electric light, the question having recently come prominently forward in connection with the difficulty of extending the present gas-works.——It is reported that the installation of the electric light at the Cogry Mills, Belfast, has been so successful that it is probable the light will be introduced on a large scale into neighbouring establishments.

Bowness.—At a meeting held last week, the Bowness Local Board had under consideration the question of the electric light installation, the result being that the Board was in favour of a Company undertaking the lighting of the town, on condition that

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the contract was entered into with the Local Authority on terms favourable to the ratepayers. Messrs. R. H. Fell and Son will most probably be granted permission to lay electric cables along the main roads of the district.

CHATHAM.—A scheme for the purchase by the Town Council of the property of the Water and Electric Light Companies came before the last meeting of the Council, but was adjourned to the next meeting, not, however, before some notes which had been prepared by the Mayor had been distributed. It is understood that the proposal is viewed with favour by many members of the Council.

DEWSBURY.—It is stated that a poll of the inhabitants of Dewsbury will shortly be taken to settle the question whether the township is to be lighted by electricity or gas.

MIDDLESBOROUGH.—It has been decided to form a sub-committee to prepare a report on the question of electric lighting for the town.

SYDNEY, NEW SOUTH WALES.—In reference to the electric lighting of Sydney, a Paper was recently read before the Royal Society, Sydney, by Prof. Selman, suggesting that the high-tension direct current transformer system should be used in lieu of the scheme which has been previously under consideration.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

September 3, 1892.

15,833. W. P. THOMPSON. Liverpool. Improvements in telegraphic apparatus. (L. Dill, Germany.)

15,840. R. E. B. COMPTON and E. A. N. POCHIN. London. Improvements in electric arc lamps.

15,865. C. W. ATKINSON. London. Improvements in electrical switches.

September 5, 1892.

15,876. J. MUIRHEAD. Glasgow. Improvements in and relating to telephonic instruments.

15,887. H. H. FREI. London. Improvements in, and apparatus for, obtaining metals by electrolysis.

September 6, 1892.

15,958. C. J. J. COX. London. Cox's "Multum in Parvo" electric top band for boots.

15,959. E. S. and E. S. D'ODIARDI. London. Improvements in pneumo-dynamo meters.

15,960. E. S. and E. S. D'ODIARDI. London. Improvements in means of conveying or administering electricity for medical purposes or others.

15,961. E. S. and E. S. D'ODIARDI. London. Improvements in charging vapours for inhaling purposes or others with electricity.

15,962. E. S. and E. S. D'ODIARDI. London. Improved means for administering electricity to animals or human beings.

15,963. E. S. and E. S. D'ODIARDI. London. Improved means for administering or conveying electricity for medical or other purposes.

15,969. G. J. SPEED. London. Improved electric cork-ribbed belt.

15,972. SIEMENS BROS. AND CO. (LIMITED). London. Improved arrangements of pulleys and bands for driving machines from electromotors. (Messrs. Siemens and Halske, Germany.)

15,991. P. H. HOLMES. London. The manufacture and production of compositions of matter suitable for use for bearings, packings, projectile guides or rings, electrical conductors and analogous articles.

15,992. P. H. HOLMES. London. Improvements in the manufacture of composition bearings, packings, projectile guides, or rings, or analogous articles, applicable also for use as electric conductors.

15,994. P. H. HOLMES. London. Improvements in electrical conductors.

15,998. A. V. NEWTON. London. Improvements in the manufacture of electric circuits and cables. (J. A. Barrett, United States.)

15,999. A. V. NEWTON. London. Improvements in the manufacture of electrical circuits, cables and other articles alike subject to flexure. (J. A. Barrett, United States.)

September 7, 1892.

16,014. J. W. MACKINTOSH. London. Improvements in phonographs.

16,046. H. Y. CASTNER. London. An improved process of an apparatus for the electrolytic decomposition of alkaline salts.

16,055. T. R. FREEMAN and W. W. POPE. London. Improvements in dynamo-electric machinery.

September 8, 1892.

16,114. E. CURTICE. London. Improvements in signalling, announcing and advertising by electric light on the clouds or other vapour and in apparatus therefor.

15,124. A. R. BENNETT. London. Improvements relating to telephonic switching apparatus.

16,126. W. MOSELEY. London. Improvements in soldering joints of electric wires.

September 9, 1892.

16,138. H. A. C. SAUNDERS. London. Improved means for transmitting telegraphic signals through submarine and like cables.

16,142. J. F. HOFFGAARD. Manchester. Improvements in telegraphic receiving instruments. (H. P. Fryd, Denmark.)

16,143. S. HUGHES. Birmingham. Improvements in telegraphic receiving instruments.

16,154. J. F. MILLS. London. A new or improved lubricating inking apparatus for telegraphic purposes.

16,176. E. H. P. HUMPHREYS and W. FRIESE-GREENE. London. Improvements in the means or apparatus for measuring electricity.

September 10, 1892.

16,201. J. B. FACHRIS. London. Improvements in galvanic batteries.

16,254. S. T. WYAND and L. SCHRAMM. London. An improvement relating to electrical switches, sockets, cut-outs, and like electrical appliances.

16,262. C. A. FAURE. London. Improvements in the electrolytical decomposition of alkaline chlorides for the production of chlorine and alkalies and in apparatus therefor.

September 12, 1892.

16,284. W. JENNINGS. Hertfordshire. Improvements in electric call-bell indicators.

16,300. H. H. FREI. London. Improved method of and means for supplying electricity to the carbon electrodes employed in the electrolysis of fused electrolytes.

16,301. H. T. WILSON and N. SCHWAB. Birmingham. Improvements in electrical fire and burglar alarm connections.

16,315. F. E. W. BOWEN. London. Improvements relating to electric telegraphs.

16,328. E. SPRATT. London. A new principle of conveying to or from the earth electricity to human beings.

September 13, 1892.

16,335. E. M. HARRISON. London. Improvements in electric telephones.

16,371. W. H. SOLEY, W. W. PEBKINS, J. WOLSTENCROFT, W. O'NEIL and W. H. YELLAND. London. Improvements in electric lo omotives

September 14, 1892.

16,427. G. A. NUSSBAUM. London. Improvements in magneto generators, battery switch bells, and the like.

16,434. C. M. DORNAN and R. A. SMITH. Manchester. Improvements in the construction of electric light switches, cut-outs, ceiling plates, wall connectors, lampholders, and the like.

16,456. E. F. MOY and F. TEAGUE. London. Improvements in or relating to ammeters or voltmeters.

16,461. W. MAIN. London. Improvements in secondary batteries. [Date applied for under Patents Act 1883, Sec. 103, February 15, 1892, being date of application in United States.]

16,469. C. E. WEBBER. London. Improved contact fittings for movable electric lamps.

September 15, 1892.

16,489. A. L. TAYLOR. Liverpool. An arrangement for working an electrical rock drill or similar apparatus.

September 16, 1892.

16,545. A. E. J. BALL. Plymouth. Improvements in and relating to dry and other galvanic batteries.

16,550. J. F. HOFFGAARD. Manchester. Improvements in electric telegraphs. (H. P. Fryd, Denmark).

16,561. A. W. MESTON. London. Improvements in dynamo-electric machines and motors.

16,570. F. E. ELMORE. London. An improved method and apparatus for electrical propulsion of vehicles.

16,571. WOODHOUSE AND RAWSON UNITED, LIMITED, and W. S. RAWSON. London. Improvements in the connections of electric motors with the sources of electricity from which they are supplied.

16,588. P. GARUTI. London. Production of oxygen and hydrogen by electrolysis of water. [Date applied for under Patents Act 1883, Sec. 103, April 25th being date of application in Italy.]

September 17, 1892.

16,613. J. H. GREENWOOD. London. Improvements in fire alarm telegraphs.

16,614. R. R. L. ROSOMAN. Southampton. Improvements in and relating to advertising by means of electric light.

16,615. T. FROGGATT. London. Improvements in connection with electric incandescent lamps and holders therefor.

16,624. G. W. FAIRALL. London. Improvements in automatic electric winding mechanism for electricity meters operated by the aid of clockwork mechanism and for clocks.

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16,644. Siemens Bros. and Co., Limited. London. Improvements in instruments for measuring electrical currents. (Siemens and Halske, Germany.)
16,656. F. W. Plumstead. London. Improvements in or appertaining to electric light fittings.

September 19, 1892.

16,692. S. F. Wallker. Cardiff. Improvements in electrical apparatus for signalling or speaking between ships at sea, or between ships and the shore, &c.
16,700. R. Wood. Manchester. Improvements in electric fire-alarms (E. Hoyle, Russia).

September 20, 1892.

16,768. R. Pippette. London. Electrically controlled switching apparatus for telephone exchanges.
16,775. A. Marr. Manchester. Improvements in keys for opening and closing electric currents.
16,786. W. Defries and V. J. Feeny. London. Improvements in fittings for the support of electric lamps.
16,805. R. A. Scott. London. Improved portable electric search-light apparatus.
16,820. J. D. Hickman. London. Improvements in telegraphic and telephonic apparatus for establishing communications between signal-boxes and trains on the line.
16,822. T. Craney. London. Improvements in electrolytic apparatus.
16,833. F. J. Beaumont. London. Improvements in and connected with break feed appliances for electric arc lamps.

September 21, 1892.

16,866. A. Müller. London. Improvements in electrode-plates for secondary batteries.
16,877. Sir C. S. Forbes, Bart. London. Improved signalling apparatus for telephones.
16,878. E. Bailey and J. Hall. London. Improved plates for secondary batteries.
16,879. E. Bailey and J. Hall. London. Improvements in miners' electric lamps.
16,892. D. Tommasi. London. Process and apparatus for the extraction, separation, and refining of metals by electrolysis. [Date applied for under Patents Act, 1883, Sec. 103, April 1, 1892, being date of application in France.]

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

13,714. Miller. Measuring electric currents.
14,039. Reckenzaun. Electrical measuring apparatus.
15,075. Thompson and Pyne. Electric lamp.
15,299. Lake (New Haven Clock Company). Electrical signalling apparatus.
15,403. Boult. Actuating electrically propelled tramcars.
15,440. Twigg. Electric conductor.
17,119. Cheesewright. Electrical switches.
17,148. Sayers. Electrical switches.
17,581. Morgan and James. Electric insulators.
17,719. Byng. Electric battery.
17,758. Mining and General Electric Lamp Company (Limited) and Niblett. Secondary batteries.
17,818. Pyke and Harris. Electric transformers.
17,907. Swinton. Electric signalling.
18,011. Whalley. Telephone switch boards.
18,251. Siemens Bros. and Co., Limited, and Baily. Electricity meters
18,285. Burton. Electric switches.
18,423. Forbes. Telephone combination.
18,505. Cleveland. Electric circuit controller.
18,524. Thompson (Hewett and another). Electric conductors.
18,551. Hall. Electric terminals.
18,775. Siemens Bros. and Co. (Limited) and others. Electric bell indicators.
18,974. Parker. Electrical furnaces for making phosphorus, &c.
19,225. Siemens Bros. and Co., Limited, and Schloemer. Electrical indicator.
19,314. Lake (Société dite Electriciteits Maatschappij [System de Khotinsky]). Incandescent electric lamps.
22,627. Hollingsworth. Electric locomotives.

1892.

1,571. Frenot and Nouvelle. Incandescent electric lamp.
1,737. Boult (Ellis). Electric clock mechanism.
3,869. Elliott. Electrical push button.
7,264. Harrison. Electric arc lamps.
7,404. Short. Electric railways, &c.
7,404a. Short. Dynamo-electric machines.
9,331. Grantland. Electric propulsion of railway cars, &c.
10,145. Holsten. Differential arc lamp.
10,357. Schneider. Electric resistances.
11,592. Mills (Pilkington and another). Ammeters, &c.
11,617. Hall. Dynamo machines.
11,849. Bergmann. Electric circuit boxes.
11,948. Cortland. Electric fire alarms.
12,238. Scheithauer. Electric currents.
12,818. Evans-Jackson (Huestis) Electric railways.
13,167. Irish. Electric arc lamps.
13,221. Deckert. Telephones.
13,549. Andersen. Dynamo-electric machines.
13,559. Cerpaux. Telephonic plant.
13,648. Dewey. Electric railways.
13,919. Thomson. Incandescent electric lamps.
13,996. Henry. Electrical generators.

COMPANIES' MEETINGS & REPORTS.

Brush Electrical Engineering Company (Limited).

The following is the third annual report of the Directors of this Company, to be presented to the shareholders at the general meeting to be held at Cannon-street Hotel, London, E.C., this day (Friday), the 30th inst., at 3 p.m.:—

The profit and loss account to 30th June last shows a gross profit of £55.757. 11s. 3d., inclusive of the amount brought forward from last account. After deducting standing charges, maintenance of buildings, plant and patents, and interest on debentures and New Debenture Stock, there remains a balance of £27,660. 15s. 8d. The Directors recommend that, as in former years, £3,000 be applied to reduction of property, patents, and goodwill accounts, and £800 to reduction of preliminary and other expenses account. An interim dividend at the rate of 6 per cent. per annum, upon both Preference and Ordinary shares, absorbing £11,553. 16s. 1d. has been paid for the six months ended December 31, 1891, and the Directors recommend that £11,553. 16s. 1d. be applied to the payment of a further dividend, making 6 per cent. per annum upon both classes of shares, the balance of £753. 3s. 6d. being carried forward to next account.

With a view to providing additional capital for extensions at the Loughborough Works, and to enable the Company to deal adequately with contracts on hand for electric lighting and other work in the City of London and elsewhere, the capital account has during the past year been increased by the issue of shares to the amount of £11,223. During the year the £75,000 Six per Cent. Mortgage Debentures of the Company have been redeemed by the issue of £125,000 Four and a-Half per Cent. Perpetual Debenture Stock, of which the major portion was issued to holders of the £75,000 Mortgage Debentures at the rate of £110 Four and a-Half per Cent. Debenture Stock for each £100 Six per Cent. Mortgage Debenture. The amount of this premium has been added to the property, patents, and goodwill account.

The capacity of the Company's works at Loughborough has been increased during the past year by the erection of additional buildings and plant, and the Company is now in a favourable position for undertaking large central station and other contracts. Further additions, with a view to the concentration of the Company's manufacturing operations at Loughborough, are now in progress. The locomotive and rolling stock department continues satisfactory, and important contracts have been carried out during the year. The vertical steam engines manufactured by the Company specially for driving electrical machinery also continue to grow in favour, and numbers have been supplied to other firms engaged in the electrical industry.

Satisfactory advance has been made with the City of London electric lighting contract referred to in the last report, and the plant already installed is now regularly supplying public and private electric lighting in a large part of the City of London. The plant, so far erected for the City of London Electric Lighting Company, represents only a small portion of the total work to be done for that Company, and, in view of the numerous applications which have been received for light in the City of London, it may fairly be anticipated that the work to be executed during the current year under this contract will add very materially to the volume of business. The Company has also during the past year secured large contracts from municipalities for the equipment of electricity supply stations in several of the leading towns of Great Britain; and the prospects of other local authorities deciding to carry out central station works, and of this Company sharing fully in the execution of such orders, are encouraging.

The Directors deemed it advisable to make a comprehensive exhibit of the Company's manufactures at the recent Crystal Palace Electrical Exhibition, and there is every indication that the results will justify the course adopted. The whole of the cost connected therewith has been written off in the profit and loss account before arriving at the net balance shown.

The Directors submit, as before, a separate balance-sheet of the Company's foreign and colonial branches at Vienna, Temesvar, and Australia. The Austrian and Hungarian businesses of the Company have made good progress during the past year. Negotiations in connection with a re-arrangement of the Company's interests in both businesses are still in progress. The policy of establishing a branch of the Company in the Australasian Colonies is now bearing fruit. Some important contracts and sales have been effected, and others are under negotiation. The Company own the Edison patents throughout Australasia; and recent decisions in

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the New South Wales Courts have confirmed these patents as controlling the sole right to the manufacture and supply of incandescence lamps.

Mr. E. Garcke has resigned the position of Managing Director, but retains his seat at the Board. Messrs. John S. Raworth and R. Percy Sellon, who formerly held the positions of Chief Engineer and Assistant-Manager respectively, have been appointed Joint Managers. Mossrs. E. Woods and E. Garcke retire by rotation, and offer themselves for re-election, and Messrs. Cooper Brothers and Co., the auditors, offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

BATES STEEL COMPANY (LIMITED).—Capital £350,000, in £10 shares. To acquire, develop, and turn to account certain patents and patent rights granted to F. G. Bates for an improved process for use in converting iron or low-grade steel into high-grade steel.

CHARLES JORDAN AND SONS (LIMITED),—This Company has been registered with a capital of £30,000, in £10 shares, to carry on at Newport (Mon.) and elsewhere the business of steel, iron, and brass founders, mechanical and manufacturing engineers, ship repairers, &c.

DI-BASIC IRON AND STEEL (PIONEER) COMPANY (LIMITED).—This Company was registered on September 24, 1892, with a capital of £200,000, in £2 shares, to acquire, develop, and turn to account the inventions of Messrs. John Heaton and G. H. Holden, of 41, Corporation-street, Manchester, relating to the manufacture of iron and steel, and to carry on the business of metal workers, boiler-makers, electricians, mechanical and electrical engineers, manufacturing chemists, &c.

GLOBE ENGINEERING COMPANY (LIMITED).—This Company has been registered, with a capital of £40,000, in £5 shares, to carry into effect an agreement between A. G. Brown and this Company, for the acquisition of the undertaking of ironfounders, iron and steel manufacturers, engineers (mechanical and electrical), tool makers, &c., to acquire patents and inventions of every description, and to develop and turn to account the same.

MISCELLANEOUS.—BROOKES AND CO. (LIMITED), iron and steel workers, wire drawers, &c.; capital, £5,000, in £1 shares.——EXCELSIOR STEEL AND IRON COMPANY (LIMITED), iron and steel manufacturers, mechanical and electrical engineers, &c.; capital, £5,000, in £10 shares.——REFEREE CYCLE COMPANY (LIMITED), cycle manufacturers, electricians, electrical engineers, &c.; capital, £25,000, in £1 shares.

CHINA AND JAPAN TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to June 7, 1892, was filed on the 13th. The Company was registered on January 31, 1883, with a capital of £200,000 in £1 shares. At the time of making up 14,761 shares had been taken up, and all had been issued as fully paid.

COLUMN PRINTING TELEGRAPH SYNDICATE (LIMITED).—The annual return of this Company, made up to February 15, 1892, was filed on August 20th. The Company was registered on August 3, 1889, with a capital of £10,000 in £50 shares; and in May, 1890, the capital was raised to £25,000 by the creation of 300 new shares of £50 each. At the time of making up 209 shares had been taken up, of which 100 had been issued as fully paid. Upon the remaining 109 shares £31. 5s. per share had been called, resulting in the payment of £3,177, and leaving £212. 10s. in arrears (*i.e.*, according to the return, which figures are, however, incorrect).

CORIFACT SYNDICATE (LIMITED).—An agreement was filed on September 5th between William A. Burrows and John W. Savage of the one part, and the above-named Company of the other part, providing for the sale to the Company of certain letters patent, inventions, and secrets for the industrial utilisation of heather waste for the sum of £11,100, to be satisfied by the allotment of 11,100 fully-paid shares in that Company. The Company was registered on April 23, 1892, with a capital of £15,000 in £1 shares, to carry on the business of artificial leather and leather board manufacturers, electrical apparatus manufacturers, insulated wire manufacturers, &c.

EASTON AND ANDERSON (LIMITED).—The annual return of this Company, made up to May 13, 1892, was filed on May 21st. The Company was registered on June 4, 1888, with a capital of £250,000 in £100 shares, being afterwards divided into 2,060 ordinary and 440 Five per Cent. Preference Shares of £100 each. At the time of making up all the ordinary and 184 preference shares had been taken up, the ordinary shares having been issued as fully paid. The full amounts have been called and paid on the preference shares.

EXCHANGE TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to August 12th, was filed on the 19th. The Company was registered on March 28, 1872, with a capital of £200,000, in £10 shares, to erect, maintain, and work telegraphs and transmit telegrams in accordance with a licence granted by the Postmaster-General. At the time of making up the capital consisted of £246,250, divided into 8,125 "A" and 16,500 "B" shares of £10 each, all of which have been taken up, and 2,125 "A" shares have £8 considered as paid on each, and 16,200 "B" shares have been issued as fully paid upon the remaining 6,000 "A" shares, the full amount had been called resulting in the payment of £53,898, leaving £102 in arrears.

EXETER ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to August 20th, was filed on the 23rd. The Company was registered on March 9, 1888, with a capital of £20,000, divided into 1,990 ordinary and 10 founders' shares of £10 each. At the time of making up, 1,008 shares had been taken up, the full amounts called resulting in the payment of £9,880, leaving £200 as yet unpaid.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY.—The Directors of this Company have declared an interim dividend for the quarter ended September 30th of 12s. 6d. per cent. on the ordinary stock, and 25s. per cent. on the preferred stock, less income-tax, payable on November 1st to the stockholders registered on the books of the Company on September 30th.

BLACKPOOL ELECTRIC TRAMWAY COMPANY (LIMITED).—An extraordinary general meeting of this Company was held at Blackpool on Saturday for the purpose of winding up the Company, the Directors having accepted an offer of £15,750 from the Corporation for the whole of the plant, stock, &c. Mr. J. Horsfall presided, and proposed that the Company should be voluntarily wound up. Mr. Thomas Bottomley, of Marsden, near Huddersfield, seconded the motion, and after a short discussion the resolution was passed unanimously. Upon a vote of thanks to the Chairman being proposed, Mr. J. Wheway said that the Blackpool Corporation had not treated the Company with the consideration they merited. The tramway had been one of the principal means of bringing people into the town, but the bargain which the Corporation had struck in purchasing the trams reflected dishonourably upon them. After some confusion the vote of thanks was carried, and the proceedings concluded.

BRITISH GUIANA ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).—The half-yearly meeting of this Company was held on August 25th, Mr. A. Weber in the chair. The six months' working had resulted in a deficit of $4,947·60, but the causes were held by the Chairman to be of an exceptional character, and not likely to recur. The revenue from private lighting was rapidly increasing, the receipts for the six months ended June 30, 1892, being $3,609, as compared with $1,172 in the corresponding period of 1891.

CALLS DUE.—*Oct. 1.*—COLLIER TELEPHONE AND ELECTRICAL MANUFACTURING COMPANY, £2. 10s. on 5,000 ordinary £10 shares; ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY, 15s. (final) on 20,500 perpetual Ten per Cent. Preference £2 shares. *Oct. 3:* NEW TELEPHONE COMPANY, £2 on 48,800 ordinary £10 shares. *Oct. 31:* ISLINGTON AND GENERAL ELECTRIC SUPPLY, £1 on 45,000 £5 shares.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 25th were £768, as against £708 for the corresponding period of last year, being an increase of £60. The total receipts for half-year amount to £9,971, against £9,126 in the corresponding period of 1891, being an increase of £845.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The list of subscriptions opened on Wednesday last, and closes this day (Friday) at 4 p.m. for both town and country, of an issue of 20,000 Six per Cent. Preference Shares of £10 each in the above Company. The shares are issued at par, and are payable £1 on application, £1 on allotment, £2 on November 15th, £2 on January 16th, £2 on March 15th, and £2 on May 15th next. Applications from holders of the ordinary shares will have preference. The issue is for one-half of the £400,000 which the Directors have power to issue, and it is intended to issue the remaining 20,000 shares towards the middle of 1893 at a premium. The prospectus states that at the present time current is being supplied to public street lamps and to about 16,000 incandescent lamps of private consumers, and that it is estimated that the additional capital now issued will enable the Company to supply current to about 150,000 private lights. The Company has laid more than 320 miles of mains, and 90 miles of cable have been already drawn in. The Directors estimate that the net revenue derivable from the private lamps, for which applications have already been received, will more than cover the full interest on the present issue, for which it is intended to apply for a Stock Exchange quotation. Prospectuses, &c., can be obtained from the bankers and brokers, the former being the London and Westminster Bank, Lothbury, E.C.; and Messrs. Sir Samuel Scott (Bart.) and Co., of Lothbury, E.C., and 1, Cavendish-square, W., and the latter, Messrs. Foster and Braithwaite, 25, Austinfriars, E C. The offices of the Company are situate at 1 and 2, Great Winchester-street, E.C., the secretary being Mr. J. Cecil Bull.——Application has been made to the Stock Exchange Committee to allow the further issue of 9,848 of the Company's ordinary shares, Nos. 70,153 to 80,000, to be quoted in the Official List.

COMMERCIAL CABLE COMPANY.—The Commercial Cable Company's office at 4, Charing-cross, has been removed to 1, Northumberland-avenue (opposite the Grand Hotel), W.C.

DIVIDENDS PAYABLE.—*Oct. 1:* COMMERCIAL CABLE; DIRECT SPANISH TELEGRAPH; HENLEY'S TELEGRAPH WORKS. *Oct. 14:* EASTERN TELEGRAPH. *Oct. 15:* EASTERN EXTENSION TELEGRAPH. *Oct. 18:* GLOBE TELEGRAPH AND TRUST.

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ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—Mr. J. Spencer Balfour, M.P., has resigned his position as a Director of the above Company.

EVERED AND CO. (LIMITED).—The Directors of this Company have declared an interim dividend at the rate of 7½ per cent. per annum for the half-year ended June 30th last.

WATERLOW AND SONS (LIMITED).—A dividend of 3 per cent. on the preference shares, making 6 per cent. for the year, and an interim of 4 per cent. on the ordinary shares, has been declared, both payable this day (Friday).

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 23, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,009.

WESTERN UNION TELEGRAPH COMPANY.—The Directors have declared the regular quarterly dividend of 1¼ per cent. It has been decided to recommend to the next annual meeting of stockholders, to be held next month, that the capital stock of the Company be increased from $86,000,000, as it now is, to $100,000,000.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. Sept. 21.	Price Wednesday, Sept. 28.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 28. Highest.	Lowest
			TELEGRAPHS.			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	48 49	48 49	5 7 0	Jan., Apr., July, Oct.	48½	..
£2,876,140	Stock	25/0	Do. Preferred	89 90	89 91	6 3 7	" "	91	89
£2,876,140	Stock	5/0	Do. Deferred	10¼ 10⅞	9⅞ 10¼	..	" "	10	9⅝
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¼ 11⅞	11 11½	6 1 9	Mar., June, Oct., Dec	11⅛	..
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1¾	Commercial Cable Capital Stock xd	160 165	155 165	4 4 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11 12	11¼ 12½	6 8 0	February and August	11⅞	11¼
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3⅛ 3⅜	3⅛ 3⅜	4 16 9	April and October	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅛ 11⅜	11⅛ 11⅜	5 18 2	Jan., Apr., July, Oct	11⅜	11⅛
400,000	10	5/6	Eastern	14⅞ 15⅛	14⅞ 15⅛	4 6 8	" "	15⅛	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16	15½ 16	3 15 0	" "	16	..
£1,200,00	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111 113	111 114	3 10 2	May and November	112¾	111
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15 15½	15⅛ 15⅝	4 11 1	Jan., Apr., July, Oct	15⅝	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	109 112	3 11 5	February & August	110½	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July	104¾	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103 106	103 106	3 15 6	February & August	..	..
180,227	10	3,9	Globe Telegraph and Trust	10½ 10⅝	10½ 10⅝	4 12 4	Jan., Apr., July, Oct	10⅞	10½
180,042	10	6%	Do. 6 per Cent. Preference	15⅝ 15⅞	15⅝ 15⅞	3 16 10	" "	15⅞	15⅝
150,000	10	5,0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	18⅞	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	103½	..
17,000	25	37/6	Indo-European	42 44	42 44	5 13 8	May and November	44	4 ½
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October	7½	..
3,381	£100 Cert.	£1⅞	Submarine Cables Trust 6%	116 121	116 121	4 19 2	" "	..	..
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	102½	101
30,000	10	2,0	West Coast of America	3 4	3 4	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	..	..
88,321	10	6d.	West India and Panama	1 1½	1 1½	..	" "	1⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 9⅝	9½ 9⅝	6 3 1	May and November	9⅛	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
64,242	15	6/0	Western and Brazilian	9 9½	8⅞ 9¼	6 9 8	" "	9	8⅞
33,129	7½	1/8	Do 5 per Cent. Cumulative Preferred	6½ 6⅝	6½ 6⅝	5 11 1	" "	6⅝	6⅝
33,129	7½	4/6	Do. 5 per Cent. Deferred	2⅞ 3⅛	2⅞ 3	..	" "	3	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123 128	123 128	5 9 5	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	97 102	97 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	1/16 1/8	1/16 1/8	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅞ 5	4⅞ 4¾	6 3 1	June and December	4⅞	4⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13¾ 14½	13⅞ 14½	4 4 3	" "	14½	14⅜
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13½ 13⅞	13½ 13⅞	4 7 3	" "	13⅞	13⅞
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	109 111	111 113	3 19 8	January and July	112¾	111¾
48,000	£10	..	New Telephone, Limited (£2 paid)	..	1 1½	..	..	1⅝	1½
58,000	5	1/0	United River Plate	1 2	1 2	..	January and July	2	1⅝
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	—	..	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	10½ 10¾	10⅜ 11	..	—	11	10⅞
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	—	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..	..	..	..	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	..
8,332	£5	..	House to House Electric	2½ 3½	2½ 3½	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5½	5 5½	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 5⅝	5½ 5⅝	5 4 4	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16	3 7/16 3 9/16	3 15 9	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	4 6 9	March	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6¾ 7¼	6½ 7	..	—	6¾	..
£50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	..	102 105	4 15 3	June and December	104	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 4½	4 4½	—	—	..	..
18,680	£5	2,6	St. James' and Pall Mall	7¾ 8¼	7¾ 8⅛	—	..	..	8¼
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	—	—	8¼	..
44,853	5	3%	Westminster Electric Supply (fully paid)	5¾ 6¼	6 6½	2 6 2	..	6¼	6¼
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1,9	Brush Electrical Engineering	3⅛ 3⅜	2⅞ 3⅛	..	..	3⅛	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2 2⅛	5 6 8	..	2⅛	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼ 5⅜	5¼ 5⅜	6 1 9	January and July	..	..
12,139	5	17%	Edison and Swan United	.. ..	.. ..	—	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	2¾ 3¼	..	—	..	..
45,000	£0	12/0	Electric Construction	4½ 5	4½ 4⅝	..	—	4⅝	4⅝
70,000	2	10/0	Elmore's Patent Copper Depositing	2¼ 2⅜	2⅜ 2⅝	—	—	2⅛	1⅞
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha & c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22⅛	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/8 ¼	3/8 4/3	..	..	..	..
78,949	5	2,9⅜	Swan United (£3. 10s. paid)	3½ 4	3½ 4	9 12 6	May and November	4⅛	3¾
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	43 45	5 6 8	March and July	44½	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	½ ¾	..	—	..	..
—	£5	8%	Do. Preference (fully paid)	.. ..	2½ 3	..	—	..	..
			RAILWAYS AND TRAMWAYS.						
50,000	£10	½%	City and South London Railway	2½ 3½	2½ 3½	1 8 6	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

The means for producing considerable quantities of liquid oxygen which have been provided at the Royal Institution, yielded during the earliest experiments most interesting results of a qualitative character, notably the discovery of the increase of the magnetic susceptibility of oxygen. As we informed our readers a fortnight ago, the low temperatures which Prof. Dewar can command have been employed by him, in collaboration with Dr. Fleming, to extend our knowledge of the electrical resistance of metals. A short Paper on this subject appears in the current number of the *Philosophical Magazine*, and is reproduced elsewhere in our present issue. It may be confidently expected that, since a large number of careful measurements have been made, some further account of them will be published, and the authors, indeed, refer to charts illustrative of their results, though no such diagrams accompany their present communication.

As the graphic representation of such observations as those which Profs. Dewar and Fleming have made are very much more easily appreciated than tables of figures, we have plotted the results and have appended the diagrams to their communication. In these diagrams we have not attempted to run regular curves through the observed points, but have merely joined them together by straight lines to prevent confusion. In order to save space, the scales are different in each case, but we have given absolute zero and zero specific resistance in all of them. The convergence of the resistances of the pure metals towards absolute zero is very clear, though a greater curvature might have been expected; in the case of nickel, for instance, it appears that perfect conductivity would be reached at about 220deg. The small slope of the alloys is well marked, and the suggestion contained in the Paper on the relation between this slope and the purity of the metals is of great interest, and promises to be of no little importance.

While the resistances of pure metals converge, as Clausius suggested in 1858, towards absolute zero, a glance at Fig. 8, p. 614, shows that the curves of carbon converge to a high temperature. The abrupt change of state of carbon at its point of volatilisation, and the enormous apparent latent heat of carbon vapour suggest that at this temperature carbon, which then behaves as an electrolyte, undergoes an important change. It is apparent from the diagram and as well, indeed, from the tables, when attention is thus drawn to the figures, that the specific resistance of carbon diminishes $1{\cdot}23 \times 10^3$ to $1{\cdot}82 \times 10^3$ C.-G.-S. units per 1°C., taking the extremes only, since the curves are practically straight lines. At this rate the resistance would disappear altogether at 3020°, 3220°, and 3520°C., for the three varieties of carbon examined. Rosetti gave the temperature of the crater of the positive carbon at 3200°C. The admirable coincidence of this result with our calculations is unfortunately rather upset by an estimate by Prof. Dewar himself, of 6,000°C. as the temperature of the arc, but, coincidence or no, the result is at least suggestive.

The communication by Lord Rayleigh in the *Philosophical Magazine* for October on the intensity of light reflected from water and mercury at nearly perpendicular incidence, has too slender a connection with electrical science and engineering to warrant its reproduction in these columns, but one or two points in the experiments and the results are of considerable practical interest. The object of the research was a photometric comparison of a direct and of a reflected ray from a glow lamp. Photography was used, and the integration of the effect during an exposure of several minutes allowed the adjustments to be made with greater facility. Owing to veins in the glass bulb it was necessary to cover it with tissue paper, and as rays proceeding from the lamp in opposite directions were used, it was rotated slowly during the whole time of exposure. At first ordinary plates were used, but as these plates were scarcely sensitive to yellow and green light, the effective light was liable to considerable variation with the current used to light the lamp. Isochromatic plates were then employed, and a yellow glass was used. The spectrum was photographed, and was well defined, lying with almost perfect symmetry between the sodium and the thallium lines. The effective wave-length was, therefore, about 5620. Under favourable circumstances it was possible to detect a difference of $3\frac{1}{2}$ per cent. in the photographic records; a few experiments could, therefore, be expected to give the required result within 1 per cent. Lord Rayleigh's photographic method of photometry, the value of which depends on the observance of these simple but important conditions, may be expected to be of considerable value in ordinary photometric work.

With the reflective power of water, viz., 0·02076 to 0·022, as measured by Lord Rayleigh, we are not much concerned,

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but the efficiency of mercury, 0·758, is of considerable importance in connection with the use of reflectors for electric light. It is not probable that reflectors coated with metallic silver are materially better than the best mirrors with mercury amalgam, and allowing for the glass and for tarnish, it must not be expected that more than 70 per cent. of the light falling on such reflectors can be returned. Accurative determinations of the reflective power, according to Lord RAYLEIGH's method, would be vitiated by very small departure from strictly plane reflectors; but a very small surface would suffice.

THE efficiency of metallic reflectors is not so important for practical purposes as that of silvered glass, because of their liability to tarnish. The following figures may, however, be of interest:—ZÖLLNER gave the reflecting power of mercury at 0·648; speculum metal, 0·535; glass, 0·040; water, 0·021. The last of these agrees well with Lord RAYLEIGH's determination, but there is a considerable divergence in the first. Sir J. CONROY found silver to be 0·70; speculum metal, 0·66; steel, 0·54 and tin, 0·4; but from the account of his experiments in *Proc.* Roy. Soc., XXXV. and XXXVI., he does not appear to have made his observations immediately after polishing the mirrors. HERSCHEL gave 0·6 as the reflecting power of mercury, and put silver as high as 0·91.

THE problem of the transmission of alternating currents along inductive cables was solved some years ago in a very complete manner by Mr. OLIVER HEAVISIDE in the pages of *The Electrician*. Several of the results then obtained have been re-proved in an article by Drs. BEDELL and CREHORE, the first part of which we publish in this issue, and the conclusions have been rendered more easily intelligible by means of curves, and by working out cases numerically. Complicated mathematics of the character here employed remains quite useless till it emerges from the symbolic form, and is reduced to actual figures. All formulæ which are useful are of a simple character; but until the practical conditions of a problem are thoroughly grasped it is impossible to foresee where approximations in the mathematical processes can safely be made. With alternating currents of ordinary frequency, the solution of Mr. HEAVISIDE can be much simplified, as was shown by Dr. FLEMING in a Paper read before the Institution of Electrical Engineers in connection with the so-called Ferranti effect. Indeed, it is obvious that, as the wave-length of ordinary alternating currents is about 2,000 miles, the conclusions of the present article regarding the effects happening at a distance of half a wave-length do not often apply on this planet. With the more rapid currents used in telephony the results became more applicable, though they have not yet been reduced to a form such that their truth can be easily put to a practical test. The problem of improving signalling on long telephone or telegraph cables is obviously one of great importance, and, unfortunately, theorists and practical men appear quite at variance as to the best way of seeking for improvement.

THE system of granting rebates to the customers of an electricity supply company, having for basis the number of units consumed *per lamp installed*, is undoubtedly the most equitable to the consumer and the most advantageous to the company, since it affords relief not only to the large but to the small consumer and tends to prevent the fixing of unnecessary lamps. But, as we remarked last week, discounts on all quarterly bills exceeding a certain minimum, although theoretically less correct, may in practice give more satisfaction, since it is possible to pay too high a price in the shape of a complex sliding scale for the boon of a perfectly fair tariff.

OUR objection to the Leeds tariff was first of all that the meaning of "supply demanded" was ambiguous; and that, presuming it meant total lamps installed, the high figure of 250 hours per lamp per quarter, or 1,000 hours per lamp per annum which had to be reached before any reduction was made in the standard price of 8d. per unit, rendered the proffered rebates somewhat illusory and, therefore, likely to cause dissatisfaction amongst consumers. Taking the experience of London supply companies, 10s. per annum per lamp connected may be considered an average income; this means at 7d. per unit a consumption of 17 units per annum, that is to say, each so-called 30-watt lamp connected to the company's mains is alight 566 hours per annum, or a little more than 1½ hour per diem.

FROM this it will be seen that the conditions at Leeds will have to be—as indeed they may—something totally different to those which obtain in London, if the average customer is to get his 10 per cent. reduction. At Exeter, on the other hand, as will be seen by Mr. T. P. WILMSHURST's table in another column, the first rebate is made when each lamp installed has been alight two hours per diem, so that in Exeter the average customer's bill may possibly be affected. The whole thing seems really too complicated, and hardly worthy of the attention of any but very large consumers, and these would, in any case, naturally make some sort of bargain.

THE Works Committee of the Dundee Gas Commission received a letter at their last meeting from Sir COURTENAY BOYLE, to whom, by-the-bye, *The Times* alluded repeatedly in a recent leading article as Mr. COURTENAY BOYLE. The *Dundee Courier* follows the example of *The Times* when quoting part of this letter, together with a number of rules and regulations for the erection and construction of fittings. The official letter from the Board of Trade approves of the system adopted by Dundee, but goes on to say that "in the case of a system of laying mains . . . in which the conductors consist of bare copper strips, supported on insulators in conduits, serious damage and even danger may result from allowing any accidental contact with earth to remain on the system." In connection with this warning it is worthy of remark that no case of damage or danger has been heard of where such mains have been laid according to the plans of the originator of the system, Mr. CROMPTON, but difficulties have in several cases beset those who have followed his lead.

THE rules, which were published in the local journal to which we have alluded, appeared at first sight to have

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emanated from the Board of Trade. We gathered from some remarks of the Chairman at the meeting of the City of London Electric Lighting Company on September 1st, that the Board of Trade contemplated the publication of yet another batch of rules, relating this time to arc lights and motors. But on making inquiry yesterday at the Electrical Department we were informed that nothing was known of these rules, and they have therefore been drawn up and promulgated apparently upon the responsibility of the Gas Commission of Dundee. The Dundee decrees forbid the wiring of gas fittings, and go into details about the fixing of meters. The cost of making a connection and fixing meter and cut-out is put at 5s. Motors are to be insulated from earth. Where arc lamps are to be "often turned on or off, a resistance must be provided to reduce the rate at which the current is thrown on." Sundry rules are made about the insulation of arc lamps and even of the holders of glow lamps, where these are used on lamp posts. The carrying out of all these paternal precepts will, of course, go on smoothly, for everything is to be done "to the satisfaction of the inspector."

Owing to pressure on our space we have been again compelled to hold over an article by Lord Kelvin, P.R.S., entitled, "To Draw a Mercator Chart on One Sheet, Representing the Whole of any Completely Continuous Closed Surface." For the same reason a lengthy letter from Mr. C. E. Kelway in reply to one from Lieut. Bacon, R.N., which appeared on page 595 of our last issue, has been kept back until next week.

The Edison Lamp Patent.—This Patent has been upheld by the United States Supreme Court.

Middlesborough.—The Town Council have decided to apply for an Electric Lighting Provisional Order.

The Endowment of Science.—The Conseil Général de l'Isère have voted £20 towards the foundation of a course of electricity at the Grenoble Faculté des Sciences.

St. Marylebone Vestry.—The Works Committee of this Vestry have under consideration the desirability of adopting electric lighting in the main streets of the parish.

The North Metropolitan Tramways Company.—At their last meeting the London County Council decided by 92 votes to 24 to purchase a portion of this Company's system.

Accrington.—At a meeting on Monday last the Town Council sanctioned the scheme for the purchase of land, and the erection, at a cost of under £10,000, of an electric lighting station.

Stuttgart.—The electric tramway built by the Allgemeine Elektricitäts Gesellschaft in Stuttgart has been completed, and is now being worked for the stipulated period of three months before being taken over by the authorities.

Obituary.—We regret to announce the death, at the age of 63, of Dr. Alexander C. Kirk, senior partner in the firm of Messrs. Robert Napier and Co., shipbuilders, of Glasgow, well-known as constructors of the principal cable ships.

Manchester.—A deputation of members of the Manchester Corporation visited Glasgow last week for the purpose of getting information as to the gas and electric lighting undertakings which the Glasgow Corporation have under their charge.

Glasgow.—The Electric Lighting Committee expect to be in a position to begin supplying current from the new station to private consumers not later than December 1st. It is further expected that the illumination of the principal streets in the central district of the city will be accomplished before the close of this year.

Military Projectors.—Experiments have recently been carried out at St. Petersburg on the illumination of the ground surface by means of electric projectors placed on a balloon floating at a height of nearly 2,000ft. More exhaustive tests will shortly be carried out at some forthcoming siege operations at Ivangorod.

Blackpool.—According to a statement made at the Town Council on Tuesday, the arrangements for providing the town with the electric light are near completion. A tender of £18,709 for the whole of the plant was accepted by the Council, who intend to use the same dynamos for running the trams during the day and for generating current at night.

Inter-urban Telephony in Australia.—The establishment of telephonic communication between Melbourne, Sydney, and Adelaide has been reported against by the Inter-Colonial Postal Conference. The initial cost of the line between Melbourne and Adelaide (350 miles) was put down at £18,223, and the annual outlay necessary at £3,233; for the line between Melbourne and Sydney (400 miles) the estimated cost was £18,000, and the annual outlay £3,200.

Electric Lamps for Customs Officers.—In order to avoid the possibility of explosion while searching for contraband goods on board tank and other vessels carrying petroleum or explosives, the Customs officers are in future, by order of the Customs Board, to be supplied with electric lamps of a special pattern. Ruby-coloured lights for the examination of imported cases of photographic negatives in a dark chamber are also to be supplied to obviate the risk of premature development.

The Cape Colony Telegraphs.—The Postmaster-General of Cape Colony, in his report for the year ending July last, states that the revenue of his department was £250,056, being £14,500 over the revenue for 1891. The only decrease was £1,227 in telegraph receipts, which fell to £66,761. The number of paid messages, 839,292, and of Government messages, 104,049, showed a decrease of 13,965 and 5,581 respectively; but the railway messages, 377,402, showed an increase of 29,812.

Copper.—On the 30th September the total stocks in England and France and the shipments advised from Chili and Australia aggregated 58,482 tons, against 59,718 tons on the 31st August. This diminution has been caused by a falling off in supplies rather than by an increase in deliveries. The former were only 7,132 tons—with one exception the smallest monthly aggregate in the present year. The deliveries are returned at 8,368 tons—also, with one exception, the smallest of the year.

Steel Trolley Wires.—A recent extension of the electric street railway system of Ottawa, Ont., is made interesting says the *Western Electrician*, by the use of steel instead of copper for the trolley wires. Sliding instead of rolling contacts are used, and it is intended to ultimately use copper cross wires from the feeders instead of steel, as at present. The idea is to make use of a harder metal to withstand the friction of the trolley contact, and to make up for the loss of conductivity resulting from this substitution by the use of copper instead of steel cross wires.

A Curious Lightning Discharge.—In a letter to *Nature* Dr. Oliver Lodge reports that on July 3rd last what was described as a fire ball was seen to strike the ground near the lake in Sefton Park (Liverpool), a column of water about 60ft. high being shot up from the lake itself. On examining the spot, holes 4ft. deep and from 7in. to 2in. in diameter were found, terminating in a drain pipe which was shattered. It seems curious that the lightning should have made use of a drain pipe 4ft. below the soil to get at the water of the lake. The spot struck was a simple grass slope about midway between a tall boathouse and a drinking fountain; small trees were also in the neighbourhood.

Lectures to Electrical Trades Artizans.—A local branch of the Electrical Trades Union has been formed at Glasgow, and by way of showing that it is sought to make the members

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proficient in their work, the Union Committee has organised a course of lectures on trade subjects for the ensuing winter. The course will be inaugurated next month by Mr. H. A. Mavor, M.I.E.E., and on that occasion Lord Kelvin will preside. The other lectures, which are to be given monthly, are to be delivered by Mr. Rankin Kennedy, Mr. Sam. Mavor, Mr. William McWhirter, Mr. W. B. Mountain, and Mr. R. D. Smillie, all of whom are closely identified with the electrical industries of Glasgow and the West of Scotland.

Artificial India-Rubber.—Dr. W. A. Tilden discovered some months ago that isoprene, which can be prepared from turpentine, under certain circumstances changes into what appears to be genuine india-rubber. Bouchardat had also found that the same change could be brought about by heat. The material so produced resembles pure Para rubber in every way, and, whether it is genuine rubber or not, it may be equally good for all practical purposes. It vulcanises, for instance. It, therefore, seems possible, says *Industries*, that we may soon be able to make india-rubber commercially. If this is possible, a fortune awaits the inventor who can make good rubber from turpentine at a reasonable price. It is a subject well worthy of the devotion of prolonged labour.

The Scott Flash-Signalling Lantern.—The Brazilian cruisre "Tiradentes," built and equipped at Elswick, went through her trials a few weeks back. After the trials the signalling lamp, invented by Commander Scott, of H.M.S. "Excellent," was exhibited and created great interest. The lamp in question, which was described in *The Electrician*, Vol. XXV., pp. 171 and 473, is designed to send signals by the usual flashing method. The lamp can be placed on the top of the mast, or on a special signalling pole; an all-round sphere of action is therefore afforded to it. The operator, however, can be posted wherever convenient. He works the lamp by means of a key. Each time the key is pressed the lamp emits a flash, shutters surrounding a glow lamp being actuated by a system of electro-magnets.

Prize for a Microphone.—*Nature* announces that Baron Léon de Lenval, of Nice, offers a prize of 3,000 francs to the inventor of the best application of the principles of the microphone in the construction of a portable apparatus for the improvement of hearing in deaf persons. Instruments for competition should be sent to Prof. Adam Politzer, or Prof. Victor von Lang, Vienna, before December 31, 1892. The prize will be awarded at the Fifth International Otological Congress at Florence in September, 1893. If no instrument is judged worthy of the prize, the jury reserve the right of announcing another competition, unless Baron Lenval decides to dispose of the prize otherwise, The following are the members of the jury:—Prof. Adam Politzer (President), and Prof. Victor von Lang, Vienna; Dr. Benni, Warsaw; Dr. Gellé, Paris; Prof. Urban Pritchard, London; Prof. St. John Roosa, New York; Prof. Grazzi, Florence.

The Franklin Institute (Philadelphia).—We have received an advance proof of the programme of lectures at this Institute for the season 1892-93. Amongst the lectures we note the following ones of interest to electrical engineers:—November 21st, Mr. G. H. Babcock, "The Genesis and Exodus of Steam;" December 2nd, Mr. J. M. Dodge, "Rope Power Transmissions;" December 12th, Mr. T. C. Martin, "Electricity in the Modern City;" December 19th, Mr. George Faunce, Superintendent Pennsylvania Lead Company, Pittsburg, Pa., "Electro-Metallurgy and its Applications to Silver Refining and Incidentally to other Metals;" January 2, 1893, Mr. Pedro G. Salom, "The Storage Battery Question;" January 23rd, Dr. Louis Duncan, "Electric Power Transmission;" February 6th, Mr. Elmer G. Willyoung, "Electricity and the Ether;" February 24th, Mr. Nikola Tesla, "An Experimental Study of Light Effects Propuced by Alternating High Potentials;" February 27th, Mr. Clayton W. Pike, "How we Measure Electricity."

Scarborough.—At a special meeting of the Town Council held last Friday, the minutes of the Sanitary and Lighting Committee, which contained a report of the Electric Lighting Sub-committee, were adopted. The principal clauses in the report were to the effect that Mr. A. A. Campbell Swinton should be allowed to form a company to take over the powers granted to the Corporation in 1891, such company to be formed within a period of eight weeks from October 1st. The Corporation are to have the option of acquiring the undertaking at the end of 21 years upon paying for the undertaking as a going concern including goodwill (but without any allowance for compulsory purchase), such valuation to be made on a basis that the powers of the Company will cease at the end of the thirty-second year, and upon the further basis that the dividend paid by the Company shall be taken not to have exceeded a cumulative dividend of 10 per cent. The maximum price of current for public lamps is to be 6d. per unit, with sliding scale reductions, after payment of an 8 per cent. dividend, and after making due allowance for depreciation and reserve. The maximum price of current to private consumers is to be 7d. per unit.

Carlow.—The *Journal of Gas Lighting* has the following remarks with reference to the Carlow incident reported in our issue of September 23rd:—

We should like to know if the facts are as stated. If so, it will only mean that somebody connected with the Carlow Gas Company has displayed a not unnatural result of mental aberration, superinduced possibly by some troublesome consumer who has been playing fast and loose between gas and electricity. There is not the remotest chance that the same performance will be repeated in any considerable town. Gas managers in general are a patient, long-suffering race. They know that their duty is to "take a back seat" whenever an electric light speculator comes into their district. They must abide in patience when the new electric lamps flaunt their hardest in the most conspicuous shops, and must allow the gas-meters to remain for the purpose of a stand-by in case anything goes wrong with the electricity. They must, without grumbling, rest content with such crumbs of rental as meters thus used bring in; and on no account must they hint that this kind of treatment strikes them as "not good enough." It is not only for the pleasure of electricians that gas companies are called upon to fill the part of the "friend in need." Whenever a local authority thinks fit to play for awhile with street oil-lamps, the gas company must pretend to take no heed, but must go on making every necessary provision in case the authority should decide to fall back upon gas at a day's notice. In the case of powerful gas companies the irritating vagaries of a few consumers do not disturb the even tenor of the way of the management; but in small places gas directors and managers, who remember that gas supply is only a business like any other, and who are not devoid of tradesmen's jealousy, are apt to act occasionally like angry men do all the world over in and out of gas works—that is to say, hastily and mistakenly.

Printing Mathematical Symbols.—The following letter from Prof. Silvanus Thompson, which appeared in *Nature* of September 29, will, we hope, appeal to that ever-increasing multitude of individuals who write incomprehensible equations in undecipherable symbols:—

Everyone who has had to correct printers' proofs of mathematical formulæ must be painfully alive to the pitfalls into which the non-mathematical compositor continually blunders. To such as know the extreme difficulty of getting such formulæ properly set up there have doubtless occurred from time to time suggestions for such simplifications of notation as shall render the composition less liable to derangement. One most sensible step of the kind I allude to is the introduction by Sir G. Stokes of the solidus notation for quotients, whereby

$$\frac{dy}{dx} \text{ is now written } dy/dx.$$

The immediate purpose of this letter is not to propound any wholesale scheme of reform, but to advocate one other simple step, and to induce some of my *confrères* to give the world their own suggestions.

Exponentials are a continual stumbling-block to the compositor, and to the printer's reader, who, when he comes to an expression like

$$Ae^{-ax}$$

does his best to make it look a little straighter, and turns it into

$$Ae^{-ax},$$

or into

$$A_e{}^{-ax},$$

or perhaps worse.

The reform I advocate is to write the thing as follows:—

$$A\ exp[-ax],$$

the square brackets being possibly omitted in all cases when their omission would occasion no confusion. One gain in this notation is the reduction of the whole of the symbols to one level, so not breaking the line of type.

Another useful reform, though one on which I fear the probability of agreement is less likely, is the use of the Continental notation for inverse trigonometrical functions, writing, for example,

$$\text{arc tan } x,$$

instead of

$$\tan^{-1}x$$

for the angle whose tangent is x. Our notation is not only liable to continual misprinting, but is very confusing to Continental readers, who again and again read the latter expression as meaning

$$(\tan x)^{-1}, \text{ or cotan } x.$$

I have even seen it reprinted in a German technical journal as

$$\tan - 1x.$$

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THE MEASUREMENT OF HYSTERESIS AND EDDY-CURRENT LOSSES IN TRANSFORMERS.

BY SYDNEY EVERSHED AND ERNEST B. VIGNOLES.

(*Concluded from page 587.*)

II.

Comparison of Observed with Calculated Loss.

In order to compare this observed loss with that calculated from the B.H. cycle obtained by our ballistic-galvanometer method added to the calculated waste by eddy currents, the transformer was put through the cycle referred to with the following results, care being taken that the maximum induction density was the same as that in Experiment II.

Experiment III.—B.H. *cycle.*

Transformer used in Experiment II. wound with $P_1 = 20$ turns; $P_2 = 40$ turns; secondary = 300 turns.

Table II.

Rising.		Falling.	
Total mag. force.	Total induction.	Total mag. force.	Total induction.
− 126	930	228·0	43,100
− 75·5	1,460	111·0	42,400
− 25	2,720	+10	40,000
+ 30	7,450	− 25	35,800
+ 49·4	15,500	− 55·5	25,900
+ 77·6	29,000	− 56·0	25,400
+112·0	36,400	− 63·0	22,400
+144·0	39,000	− 90·7	12,500
+231·0	42,800	− 87·6	13,350

These results are plotted as a curve in Fig. 7. In order to give the loss per cubic centimetre per cycle, for comparison with other curves, the curve has been plotted from the co-ordinates:—

$$H = \frac{\text{Total magnetising force}}{\text{length of iron path}};$$

$$B = \frac{\text{Total induction}}{\text{area of iron}};$$

but these co-ordinates have no physical meaning, as the length of the induction path varies nearly 100 per cent.

The falling curve is only taken to see if the difference in area due to time lag amounts to much in this sample. The curve plotted is obtained by folding back the rising curve in the manner described. Note the time-lag at the top reading. On "make" the induction is 42,800, while on breaking, although the current has fallen to 228 from 231, the induction is higher, 43,100.

The area of this curve is a measure of the average loss per cubic centimetre in the ring due to hysteresis, when the iron is carried through its cycle in about two seconds, as explained in connection with Fig. 3.

Calculating the work from the area of the curve by the formula—

$$\text{Total work in ring} = \frac{\text{area of curve}}{4\pi} \times \text{volume of ring.}$$

$$= 443{,}000 \text{ ergs per cycle.}$$

Therefore, at 100 ∿, the loss would be $4{\cdot}43 \times 10^7$ ergs per second, or 4·43 watts.

Calculation of Eddy Current Loss.

The eddy current loss was calculated from the following formula:—

$$W = \frac{\pi (\dot{B})^2 t}{6 n \rho \log_e \frac{R}{r}}$$

Where $(\dot{B})$ = effective rate of change of total induction (in volts).
t = thickness of each lamina in ring.
ρ = specific resistance of the iron in ohms.
R = outer radius, r = inner radius } of the ring.
n = number of laminæ.

(A proof of this formula will be found at the end of the present article.)

Substituting the following values in the above equation; namely:—

$$(\dot{B}) = \frac{4{\cdot}4 \times \text{total induction} \times \text{frequency}}{10^8} \text{ volts,}$$

$$= \frac{4{\cdot}4 \times 21{,}300 \times 100}{10^8} \text{ volts,}$$

$$= \frac{9{\cdot}37}{10^2} \text{, volts,}$$

$t = 0{\cdot}0414$ cm.,

$\rho = \frac{13{\cdot}5}{10^6}$ ohms, (average of 3 determinations of actual iron used),

R = 4·64 cm., r = 2·08 cm., $\log_e \frac{R}{r} = 0{\cdot}803$,

$n = 20$,

we find the total energy spent in eddy currents in the core is

$$W = 0{\cdot}88 \text{ watts.}$$

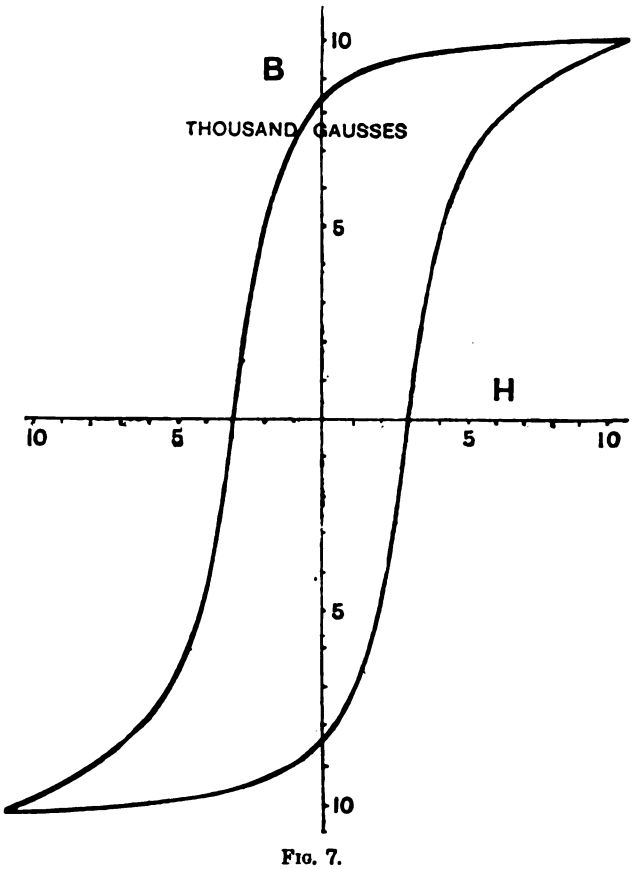

Fig. 7.

As we point out at the end of this article, this value is, for several reasons, slightly too high; but since it is only one-sixth of the total waste, an error of 6 per cent. in the estimation of the eddy current loss will only produce one of 1 per cent. in the total.

Adding these two figures, 4·43 and 0·88 watts, we get the total predicted loss, on the assumption that the work done in overcoming hysteresis at a frequency of 100 ∿ is the same as it is found to be by measurement at a frequency of about 0·5 ∿.

We have, then,

Hysteresis loss	= 4·43 watts
Eddy currents	= 0·88 „
Predicted total	= 5·31 watts
Measured total by thermometric method	= 5·40 watts
Difference between observed and predicted loss	= 1·8 per cent.

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Practical Conclusions.—The result just given will, we venture to hope, finally set at rest the vexed question of magnetic time-lag, so far as it affects electrical engineering.

Clearly the difference in the work done in carrying a piece of iron through a complete magnetic cycle in periods even so widely different as 2 seconds and 0·01 second is too small to be detected with certainty by the methods of experiment employed—it cannot possibly be greater than 4 or 5 per cent., and is probably under 2 per cent.; in other words, in designing a transformer or an alternator the hysteresis can be determined with abundant accuracy from the cyclic curve, of a sample of the iron to be used, taken by a ballistic galvanometer method. If the method used in our investigations is adopted, and the rising curve of induction only is used, no correction for time-lag is required; if, however, a method of testing is employed involving a necessarily slow cyclic period —of the order minutes rather than seconds—an indeterminate error is introduced which may amount to 20 per cent. or more of the estimated loss.

Another important conclusion should be drawn from our results by engineers, and that is that every one of the published tables of hysteresis losses for "charcoal iron of good quality" is a trap for the unwary. Prof. Ewing was, we

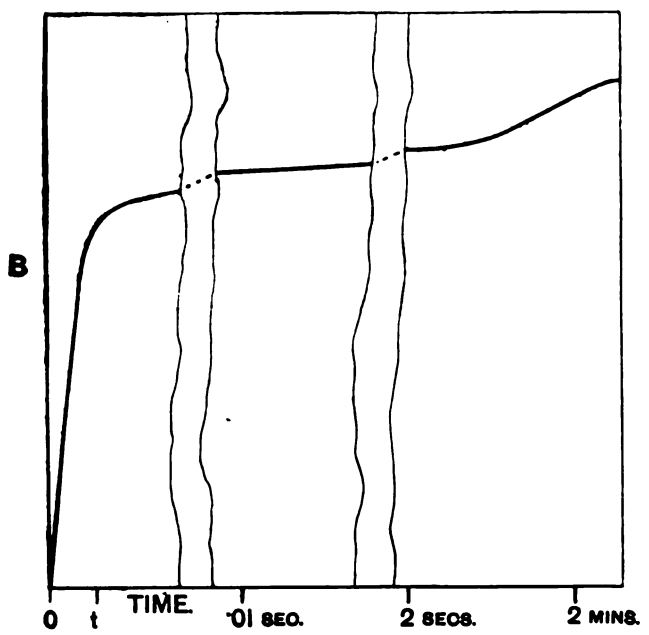

FIG. 8.—Curve illustrating Growth of **B** in Iron with time after application of **H**. t represents a time comparable with the vibration period of an iron molecule.

believe, the first to publish such a table, and his figures have been almost universally copied and adopted. Unfortunately no material is more variable in its qualities than the so-called "charcoal iron," and Prof. Ewing's results can only be held to be true for the particular samples which he used.

Mr. Alexander Siemens, Mr. Swinburne, and, since writing this article, M. Dobrowolsky have all published tests showing far higher hysteresis losses in iron than those given by Prof. Ewing; for example, Mr. Siemens found the waste some 70 or 80 per cent. in excess, and M. Dobrowolsky confirms this result. We have ourselves tested samples of charcoal iron which gave results about 20 or 30 per cent. above those of Prof. Ewing's table, but the transformer core used in the present experiments has a hysteresis waste about 90 per cent. in excess of Prof. Ewing's iron; and it must be distinctly understood that this iron and the sample just referred to were made at the same mills, sold as the same quality, and have nearly the same permeability. So that unless a manufacturer of alternators and transformers is prepared to leave the temperature of the cores to chance, letting them vary as much as 100 per cent., he must test every batch of iron sheet or wire received from the mills. The same remarks apply but of course with less force to the armature cores of direct current dynamos.

The introduction of some simple and direct method of testing samples of iron for hysteresis waste would go far towards securing more attention to quality on the part of iron manufacturers, with the natural result of greater uniformity, and we shall no doubt see the day when it will be as much a matter of course to buy and sell iron on a specification of "not more than 6,000 ergs per cc. per cycle," as it now is to specify for copper of 98 per cent. conductivity. Prof. Ewing is already in the field with a magnetic curve tracer, and his ingenious device is probably the "Puffing Billy" of magnetic testing; the "Rocket" has yet to be built.

So much for practical results. We may just emphasise the theoretical point of interest which is very clearly indicated by the experiments described. When we trace a cyclic curve very slowly—taking, say, a minute or so to complete one cycle, the curve has a certain area—to fix our ideas, say an area of 100. When we use the method already described in which the iron completes its cycle in about two seconds, we find the area has increased to about 120, but by decreasing the time to $\frac{1}{100}$ second, we do not appreciably add to the area; it is certainly not increased to more than 125.

Evidently, then, the creeping up of the induction is a slow process, for the value of the induction is practically the same after two seconds as it is after 0·1 second; but give the iron a minute or so and the magnetic chains slowly break up and the induction as slowly increases. The question naturally presents itself, would the value of the induction one-millionth of a second after the application of the force differ from that after one-hundredth of a second? The experiments hardly do more than suggest an answer, but it seems unlikely that any appreciable difference would be found until the interval of time approached the value of molecular vibration-periods. In Fig. 8 we give a curve which is a rough illustration of this view of the relation between the value of **B**, and time after application of **H**; the curve has, of course, no pretence to scale or proportion.

In this connection "molecular vibration-periods" must be understood to mean periods of the *magnetic* molecule, or *Ewing particle*, which is not necessarily identical with the chemical or physical molecule; and by exploring the hypothetical curve in Fig. 8 towards zero we might arrive at some quantitative idea of the structure of magnetic substances.

Appendix.—The formula used in the preceding article for the calculation of eddy current losses may be obtained as follows:—

Consider one stamping of the core, of inner and outer radius r and R and t cms. thick; let the axis of figure be the axis of x; any radial line bisecting the section of iron the axis of y.

Then, if M be the magnetising force due to the exciting current, the induction *density* at any radius y is

$$\beta = \frac{\mu M}{2\pi y},$$

and the E.M.F. in an element dy, dx, $y\,d\theta$ is

$$E = \dot{\beta} \times \text{area} = \frac{\mu \dot{M}}{2\pi y}\, x\, dy.$$

The resistance of the element is $\frac{\rho\, dy}{y\, dx\, d\theta}$, so that the power spent in it

$$dW = \frac{\mu^2 \dot{M}^2 x^2}{4\pi^2 \rho y}\, dy\, dx\, d\theta,$$

and the power spent in the whole stamping is

$$W = \int_0^{2\pi} \int_{-\frac{t}{2}}^{+\frac{t}{2}} \int_r^R \frac{\mu^2 \dot{M}^2 x^2}{4\pi^2 \rho y}\, dy\, dx\, d\theta$$

$$= \frac{\mu^2 \dot{M}^2 t^3}{24\pi\rho} \log_e \frac{R}{r} \quad \ldots\ldots\ldots \text{(i.)}$$

But actually not M, but the *total* induction (**B**) was known. Now,

$$(B) = \int_r^R n\, t\, \beta\, dy = \int_r^R \frac{n\, t\, \mu M}{2\pi y}\, dy = \frac{n\, t\, \mu M}{2\pi} \log_e \frac{R}{r} \quad \text{(ii.)}$$

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where n is the number of stampings in the core. Combining I. and II. we find for the power in the whole core

$$W = \frac{\pi t (\dot{B})^2}{6 \rho n \log_e \frac{R}{r}} \quad . \quad . \quad . \quad . \quad . \quad (iii.)$$

the formula which has been used in the text.

Several assumptions have been made in arriving at this result.

First that $\beta = \mu H$,

that is say, that the induction density is proportional to the magnetising force; we know that it is not, but the density is so low that no appreciable error is introduced; we are dealing with total induction only, and a different distribution of that total in the section hardly affects the result.

Secondly, we assume the magnetising force to be the same at the centre of a lamina as it is at the outside. A formula recently given by Prof. J. J. Thomson shows that it is really about 2 per cent. less; but here again the fact that the induction is a little displaced towards the outside of the iron diminishes the power spent by an entirely negligible amount.

Thirdly, we assume the conductivity of the lamina at right angles to its plane to be infinite, and this also tends to make the formula give too high a result, the error being of the *order* 2 per cent. in this case.

Now as an error of 6 per cent. in the estimation of the eddy current loss only leads to an error of 1 per cent. in the estimated value for the waste due to hysteresis and eddy currents together, it is clear that all these assumptions are justified. We must remember that the result given by the formula cannot possibly be too low, but *may* be 2 per cent. too high. To the non-mathematical mind the fact that the calculated differs from the measured loss by less than 2 per cent., will be the most satisfactory proof of the accuracy of the formula.

NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 559.*)

19. Final Splice and Completion of Repair.—The end of cable just unmoored from buoy and secured on board is now connected up to testing-room for the purpose of communicating with the shore on that side. It will be remembered that at the time of first cutting in, before buoying, the electrician instructed this end to keep watch day and night after a certain day and hour, decided by him to be about the time the ship would fetch the buoy on her return. In the old days of single cables the station whose end was buoyed was, per force, in ignorance of all that might happen to the ship during picking up and repairing, and only learnt the news upon her return to the buoy after finishing the repair. The staff would, accordingly, commence to keep watch after the specified hour, generally preferring for this purpose the mirror instrument, in which the beam of light thrown onthe wall is an effective means of attracting the attention, the slightest movement of the beam being noticeable, without the necessity of always being close to the instrument. Day and night the spot of light would be watched, three men taking it in turn to relieve each other during the twenty-four hours, and frequently, owing either to bad weather or special difficulties encountered by the ship in picking up or localising, they might be kept at this for several days, without any idea of how matters were progressing at sea. "No signs of ship" was probably a more frequent entry in the diary in those days than in the present days of duplicate cables, for now the station whose end is cut and buoyed at sea can still learn *viâ* the duplicate cable what the ship is doing, and by this means the time spent in keeping watch is very greatly reduced, for the ship does not require watch kept until she notifies by the other cable that she is up to buoy.

Speaking of interrupted communication, whether caused by the ship cutting in for repairs or a break in the cable, there is a very great contrast on important lines between the old *régime*, say of 10 years back, with only one cable, and the present with two or three to depend on. That curious experience for an important foreign or colonial seaport town to undergo, namely, to have its telegraphic communication with Europe and the civilised world completely severed for days together, is now of very rare occurrence, and we have grown so accustomed to look into our papers for news of what has occurred only a few hours ago in the remotest regions of the globe, and the commerce of the world is so largely controlled by telegraph that the habit of rapid intercourse has become a second nature, and a total interruption affects an increasingly large section of the community.

Looking back for a moment on the interruptions occurring in the days of single cables it was the usual custom to bridge over the period of interruption by sending the accumulated "through" messages on by the first steamer leaving; or if none were about to proceed that way, by one chartered specially. On the arrival of such a budget at a station there was no small excitement to transmit the same onwards at the utmost speed attainable by the operators' skill, and the capacity of the lines. Copies of all messages were, of course, kept, because the cable might be put through while the chartered vessel was on the high seas, and in that case she would be landing a batch of messages already delivered at their destination thousands of miles away, days ago. But it often happened that an interruption lasted long enough to allow several batches to cross each other by sea before communication was restored. As concerned the "local" traffic, or that immediately confined to the interrupted stations, people either posted their messages by mail or by the chartered steamer, but it was curious to notice that some whose news was of greater importance preferred to pay the piper and gain the two, three, or four days, as the case might be, by sending their messages round the other way. As the result of this there was something inconceivably odd in transmitting a message, say from Bombay to Aden, on its way to London from Hong Kong, its ultimate destination being Shanghai.

The sender of such a message would probably gain three days over the mail between these two ports in China. But it is curious that in getting from one port to the other the message would pass twice over the continents of Asia and Europe by different routes, the return route being by the Siberian lines and Vladivostock. The two ports in China above mentioned have now triplicate communication, two cables and one land line, and most lines are either directly duplicated or the duplicate cable is taken by a different route in order to call in at fresh places on the way. With such wise provision it is extremely rare nowadays to hear that any important town or colony is totally interrupted. Such can only be conceived to occur in the event of a volcanic upheaval affecting cables lying in the same region, as happened in the year 1890, on the night of July 10th, when the three cables between Java and Australia were simultaneously interrupted near the former island. There exists, of course, a large number of single cables which it would not pay at present to duplicate, but the foregoing allusions have been made to what might be called the great trunk systems connecting China, Japan, India, Australia, America and Africa with the continent of Europe.

But to return. The ship, having called up the buoyed end asks for "Free 30 seconds," in order to prove insulation good, and then "Earth 30 seconds," to ascertain correct resistance of conductor and distance from shore. Likewise, having cut the end of payed-out cable to allow sufficient length for splice, this end is connected to testing-room, and a similar "free" and "earth" taken. This gives the correct length of the line in ohms, and is compared with the length of cable in knots as increased by the repair. Sometimes the capacity is measured as well, but only if there has been some doubt about it in a recent localisation test. These tests finished, a message is sent to headquarters in terms somewhat as follow:—"Communication restored; now make final splice and return." It happens sometimes that a fault has broken out in some other cable and that instructions are sent to the ship to proceed thither as soon as she has completed this one. The electrician also sends the

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message "Free one hour, then look out" to the superintendents at each station to cover the time for making the joint and splice. Meanwhile the revolutions of the drum during paying out, as seen by the rotometer, are noted, from which the length of cable payed out is calculated. This will exceed the length picked up by a small amount, and is worked out to three places of decimals, and the record of the length of cable corrected accordingly. Further, while the splice is being made a sounding is taken, with specimen of bottom and the temperature; also the latitude and longitude of the position is entered in the log, together with the type of the two ends of cable joined together.

Turning now to the splice, it has been observed that both ends are stoppered at the bows, and further secured by slip ropes stoppered to the cables at C C (as in Fig. 70), and wound round the bollards at B B. The joint and splice are, of course, similar to others, and have previously been described, but the writer takes this opportunity of describing what is called the overlapping splice, which is in very frequent use on repairs. The sketches in Figs. 69 and 70, relative to this subject, have been kindly supplied by Mr. F. C. H. Sinclair, of the Eastern Telegraph Company. For this splice the sheathing wires on one end, which we may call the left wires, are opened out for a length of 50ft. or 60ft., and the core so exposed cut away so as to leave only about three feet for jointing. The sheathing wires on the other side

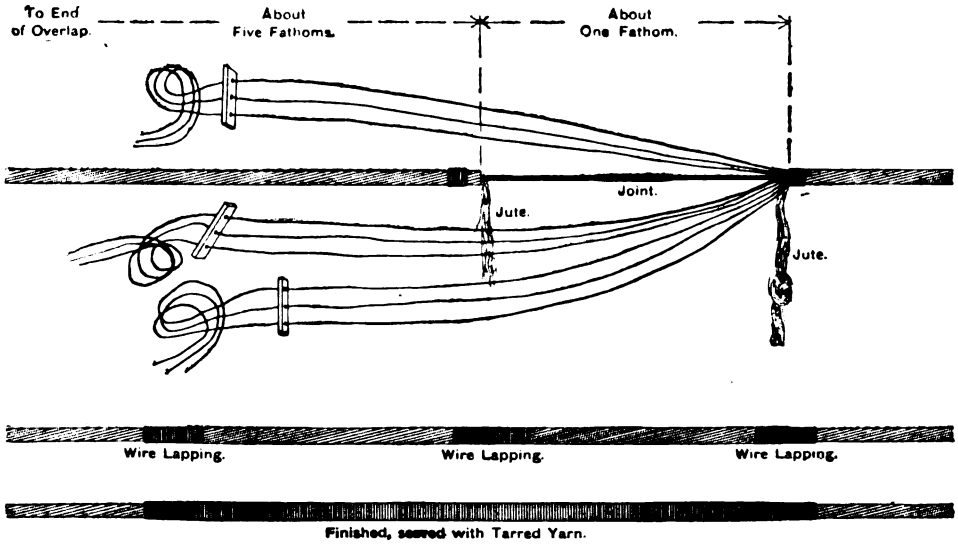

Fig. 69.—The Overlapping Splice.

—the right wires—are then cut off at a distance of about three feet, the ends being bound round with a piece of twine or yarn to prevent them opening out. This leaves three feet of core exposed on this side. The joint in the core is then made as previously described, and the jute serving, of which a sufficient length has been retained on the cable, is wrapped round it and the bare part of core. The splice between the sheathing wires is now made. The left wires are

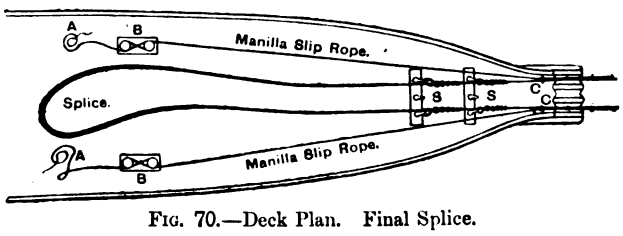

Fig. 70.—Deck Plan. Final Splice.

taken and divided for convenience in handling into bunches of three or four wires each, and in order to keep them always in the same position abreast of each other the ends of each bunch are given a twist or threaded through holes in small wood cleats, and then twisted (Fig. 69). This also gives something for the hands to lay hold of and pull on while laying the wires. The ends of the bunches are now taken in hand, and the wires laid spirally over the jute, all the wires coming properly abreast in their right positions. This first covers the joint and core, and has to be done gently until the wires are laid as far as the ends of the right wires. Then, with the assistance of the splicing tool, the wires are overlapped firmly over the sheathing of the other end, and as this proceeds soft iron wire is bound round at intervals to keep the wires in place. The splice is also tapered off by cutting away the ends of the wires at different lengths, and the whole is then served over with tarred yarn by means of serving mallets. This gives the splice a neat finish, and further increases the adhesion between the sheathings. The sketch represents first the wires opened out ready to make the splice; second the overlap as finished, with wire serving at intervals; and third, the finished splice, yarn served.

Splices are usually from 6 to 10 fathoms in length, the shorter splices being for types used in shallow water, and therefore not exposed to much strain. It is found in some types that when the wires are of iron they can be laid quite as firmly and well by hand without the aid of the splicing tool, and this is often done; but in cable of type C, where the sheathing is made up of wires alternated with yarns, or in types having sheathing wires of stiff springy steel, the work is much facilitated by the tool.

The overlapping splice just described is most often made when the two ends of cable are of different types, or, though of the same type, when they differ in lay. The lay of a cable is the distance, measured in the direction of the cable's length, in which any one sheathing wire makes a complete turn round the core. The longer the lay the less the length of sheathing wire to a given length of cable. For instance in a cable of 7in. lay, having a diameter of $1\frac{1}{2}$in. (that is, the diameter of what might be called the pitch circle of the sheathing wires, or a circle passing through their centres), each wire would be $8\frac{1}{2}$in. long in one lay, or $8\frac{1}{2}$ miles long in seven miles of cable; while in the same length of deep sea type having a 10in. lay there would only be $7\frac{3}{4}$ miles. These calculations depend upon the fact that the proportions between the length of a complete spiral, the corresponding length of cable, and the circumference of the pitch circle are the same as the hypothenuse, perpendicular and base respectively of a right angle triangle. This can be easily understood by wrapping a rectangular piece of paper once round a cylindrical surface such as a ruler. After cutting the paper or folding it so that the edges just butt on the surface, a spiral line is drawn from one end of the paper to the other, starting from the seam at one end and coming back to it at the other. Taking the piece of paper off and straightening it, it is seen that what was the spiral line is now a straight line from one corner to the other, and the ratios as given above are at once apparent. Hence in the above example the mean circumference being 4·7in., the square of the hypothenuse, or the spiral, is equal to the sum of the squares on the perpendicular and base or $7^2 \times 4{\cdot}7^2 = 71$, and the root of this

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is 8½in., which is the length of sheathing wire in one complete lay of 7in. in a cable of this size.

In the splice just described the wires on the left are not picked out in alternate pairs to leave spaces in which to lay the right wires. While this system of picking out and laying in makes a neater job and binds the wires together better, it cannot be done when the cables are of different types or lay, and the overlapping splice has proved itself thoroughly reliable when made in sufficient length to suit the type of cable, and it also takes less time to make than the other.

The splice being complete has now to be slipped overboard. For this purpose the stoppers are cast off and a turn or two of the slip ropes round the bollards taken off, while two gangs of men stationed at A A (Fig. 70) stand by the slip ropes and ease them away carefully, taking care to do so at equal speed. The weight of the bight of cable as it descends of course exerts a considerable pulling force on the ropes, but the turns round the bollards easily hold it, and the slip ropes can be eased away to a nicety. As the end of the ropes stoppered

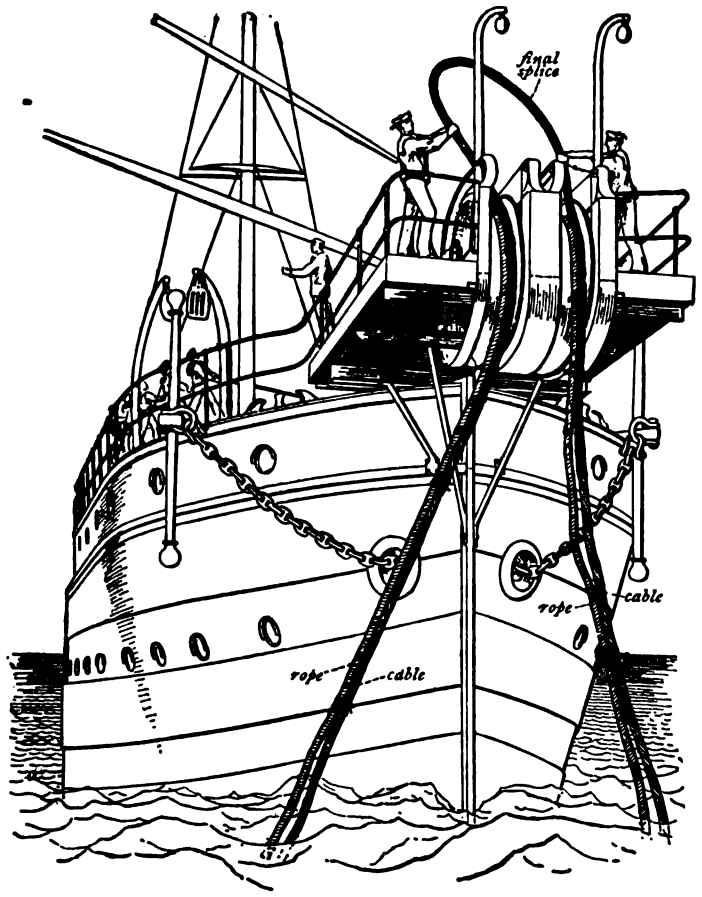

Fig. 71.—Clearing Final Splice over Bows.

to cable approach the bow sheaves the ropes are tied to the cables closer inboard, so that rope and cable on either side pass over the sheaves close together (*see* Fig. 71). This is done by men at the bows, one on each side, who continue to bind the rope and cable together with spun yarn at intervals of a few feet in this manner, while others carry the bight along the deck, keeping it open and clear of obstructions. When the bend of the bight reaches the bows it is lifted over clear of the sheaves, as shown in the illustration. The bight is then clear of the ship, and is still lowered by the ropes over the sheaves until it reaches the surface of the water. The men stationed at A A then cease to slacken out, and make fast, while a block of wood is placed at the bows under the two ropes, which are then cut through simultaneously with a sharp axe, the ends flying overboard, and the cable sinking to its resting place. The form of bow sheaves represented in Fig. 71 are provided with "whiskers" or cheeks between the sheaves for the purpose of preventing cable or grapnel rope jumping from one sheave to another when the strain comes on sideways.

We have now followed the movements and methods of practice on board a modern cable-repairing steamer from the moment of first dropping mark buoy to the moment of completing the repair and casting the final splice overboard. Incidentally some points of technical and general interest have been alluded to; but the ground to be covered in any study of this subject is very wide and full of interest, and all the more so because no two cable ships are exactly alike, and practice and methods differ in different companies. The author proposes now to discuss some of the most distinctive features of interest in different ships.

Erratum.—In paragraph 18, p. 557, *The Electrician*, September 23, Fig. 64 should have been stated to be from a photograph by Mr. W. J. Murphy, electrician on board the "Electra."

(To be continued.)

THE SUPPLY OF CURRENT BY METER.

BY T. P. WILMSHURST.

The method of charging for current adopted by the Yorkshire House-to-House Company, as published in *The Electrician* of the 30th ult., raises a question of some importance. A large number of supply companies have adopted the plan of allowing sliding scales of discounts to consumers, and of those who have no such published tables the majority find it expedient to make to their larger customers a substantial reduction of price, based on the quantity of current used.

The system in vogue is to allow a rebate to a consumer after a certain number of units have passed through his meter, irrespective of the number of lights that consumer may have. This, though undoubtedly the simplest method, is by no means an equitable one. Take the following instance. A customer, A, has 100 lamps which he uses an average of one hour per day throughout the year; B has 10 lights, and uses them 10 hours per day throughout the year. The number of units consumed by each is the same, and hence each receives the same rebate. B, however, is a far better customer to the supply company, for he helps to equalise their load curve, and only requires the use of one-tenth of the generating plant that A does,

To obtain a more even distribution of this load curve throughout the 24 hours is the fervent wish of central station officials. It was predicted that the more extended use of motors would bring about this happy result; but, unfortunately, it is found in practice that the hours of motor load overlap the hours of lighting load. One company, I believe, actually proposes to influence the lower parts of the curve by flooding the market with such apparatus as electric griddles, electric curling-tongs, and the like.

The simplest way out of this uneconomical state of affairs is, in my opinion, the application of an equitable system of rebates, which shall operate not simply on the numbers of units consumed per annum, but on the number of units consumed *per lamp* per annum. This will place the consumer with a small installation (but who wishes to use his light freely) on an equal footing with the consumer with a larger installation. Bearing these points in mind, the following table has been worked out for use at the Exeter supply station:—

Cost to a consumer of a 30-watt lamp in use for 365 days for the hours named in first column, at a sliding scale charge of—

7½d. per unit up to 12 units, 6½d. above 12 and not exceeding 16, 5½d. above 16 and not exceeding 20, and 4½d. above 20.

Hours of burning each day.	Units used per annum per 30-watt lamp.	No. of units at 7½d.	6½d.	5½d.	4½d.	Annual cost under sliding scale. £ s. d.	Average price paid per unit.	Price if at 7½d. £ s. d.
1	10·95	10·95	...	...	...	0 6 10½	7½d.	0 6 10½
2	21·9	12	4	4	1·9	0 12 3	6½d.	0 13 9
3	32·85	12	4	4	12·85	0 16 4½	6d.	1 0 7½
4	43·8	12	4	4	23·8	1 0 6	5½d.	1 7 6
5	54·75	12	4	4	34·75	1 4 6	5¼d.	1 14 4
6	65·7	12	4	4	45·7	1 8 7	5·2	2 1 0
7	76·65	12	4	4	56·65	1 12 8	5·1	2 7 9½
8	87·64	12	4	4	67·6	1 16 10	5·05	2 14 9½

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IRON LOSSES IN TRANSFORMERS.

While investigations on the magnetic properties of iron are being completed in the gradual but sure manner to which we alluded in our leading article last week, progress is being made in the kindred subject of the efficiency of transformers, and doubtful points are being cleared up. The alternate current transformer has come to be regarded, not so much as a piece of apparatus, but as natural production, a sort of animal whose habits are to be observed, or as a chemical compound which is to be analysed. In the early history of the transformer there was a difference of opinion as to how energy should be supplied to it. A change was made at the Grosvenor Gallery from series to parallel, a change of immense importance so far as both the generating and the distributing circuits and their regulation were concerned, but little or nothing was said about the transformer. Much ingenuity has been expended in designing economical stampings for the cores and in arrangement of coils to prevent magnetic leakage, but for one line on the design of transformers we read twenty on their efficiency. This may be accounted for to some extent by the fact that the subject is discussed from two very different points of view. The practical engineer is taunted by the low pressure continuous current man about his coal bill, and he vindicates his apparatus in his own way; the mathematician, on the other hand, finds that after making a few convenient assumptions about details on which he has little or no information, he can reel out yards of calculations, which, according to him, prove this, that, and the other. The practical man not understanding a word of it, cannot refute him, but sets to work to make experiments.

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From experiments, however, whether carried out with the express intention of investigation, or, as in the case of what was once known as the Ferranti effect, arising out of practical working, almost all our knowledge of this intricate subject is due. But, owing to the difficulties of measurement and unsuspected causes, several paradoxes have arisen. The behaviour of these strange creatures, transformers, when harnessed in tandem on mains having appreciable capacity, attracted a good deal of attention about two years ago, and the discussion dropped only after elaborate experiments had been described. Losses in the iron of transformers have given rise to another riddle, propounded by Mr. MORDEY, and which seemed to be backed up by experiments made by Prof. AYRTON and others. The experiments were said to be "conclusive" and "absolutely and entirely correct," and it was related how the losses in a 2½-kilowatt transformer fell off on full load to three watts. The news was most welcome to alternate current men, and not least to the breeder of the particular transformer.

We have from the first refused to accept this result ourselves, chiefly because it was supported by experiment alone. No attempt at a scientific explanation was offered, but surmises about variations in the magnetising value of an ampere turn and other sundry guesses were made, some of which are recorded in our leading article on the subject on March 20th of last year. Hysteresis in these experiments, we there remarked, was treated as a residuum, and was, after all, nearly the same order as the errors of observation. It was, in fact, the petty cash of the balance-sheet. The mystery has now been dispelled by the use of Dr. SUMPNER'S method of testing transformers, fully described in these columns on July 1st, 1891. This is "the article in the technical press" to which reference is made in the Paper by Prof. AYRTON and Dr. SUMPNER, lately read before the British Association, or rather before an audience of about a dozen during luncheon-time, and which will be found elsewhere in our present issue. If it be worth while, the former misleading experiments might be repeated with the view of discovering the error, but the important fact remains that no occult property of iron, no inscrutable conduct of the ampere turns, and no incomprehensible trick of the transformer eager as it were for "collar-work," remains to be discovered to account for diminution of iron losses. These losses prove to be practically constant.

The myth of magnetic lag is dispelled one day, and the next sees the overthrow of a conjecture which was, while it lasted, a stumbling-block in the science of magnetism. Orthodox magnetic theory is thus confirmed, and now that confidence is restored, it is possible to calculate the efficiency of a transformer at any load when the open circuit losses and copper resistances are known. Another interesting result of this Paper is the proof afforded that the efficiency increases with the frequency, owing to a falling off in the open circuit losses. This conclusion is important from the point of view of the all-day efficiency of transformers. It is, however, to some extent counteracted by the effect of frequency on regulation. Prof. AYRTON and Mr. E. W. SMITH in another Paper read at Edinburgh showed that the lower the frequency, the better the regulation of the transformer for different loads. This result may be of as much importance as the mere alteration of efficiency. Slow frequencies have been proposed by Mr. CROMPTON, and more recently by Prof. FORBES. It may be remarked that that curious beast, the Hedgehog transformer, living in a drain pipe, and declining to behave like any other of its tribe, refused to submit to Dr. SUMPNER'S treatment, and exhibited curves, bristling with peculiarities, "sometimes of a curious character" which Prof. AYRTON and his colleague "have not yet had time to fully explain." That this investigation would be made, and that definite results would be forthcoming, was to be naturally expected after the publication of Dr. SUMPNER'S method of testing transformers. It was admittedly based, *mutatis mutandis*, on Dr. HOPKINSON'S method of testing dynamos, and attacking as it does the very quantity to be examined—the losses—is of considerable importance. No sooner was it published than we heard that it had been in use every day for months past for running transformers in a factory, but such a use of what is only after all a mode of coupling up the terminals, is very different to the careful research which has been conducted at the Central Institution with the assistance of Messrs. BAILLIE, BAYLEY, and CLIFT. So numerous, indeed, have been the experiments, that in forwarding the Paper for publication to different journals different curves were sent.

ON THE ELECTRICAL RESISTANCE OF PURE METALS, ALLOYS, AND NON-METALS AT THE BOILING-POINT OF OXYGEN.*

BY PROF. JAMES DEWAR, F.R.S., AND PROF. J. A. FLEMING, F.R.S.

Several observers have studied the behaviour of metals as regards electrical conductivity at low temperatures. In particular MM. Cailletet and Bouty (*Journ. de Physique*, July, 1885) have made observations of the resistance and resistance-change with temperature of various metals at—100°C. by the employment of liquid ethylene as a cooling agent. Wroblewski (*Comptes Rendus*, 1885, Vol. CI., p. 161) measured the electrical resistances of wires of electrolytic copper at various temperatures, 100°C., 20°C., 0°C. – 100°C., and gives also figures for the comparative resistance of the same wires at the critical point of nitrogen, the boiling-point of nitrogen, and the temperature of the solidification of nitrogen. The possession of means for producing very considerable quantities of liquid oxygen as well as liquid ethylene has placed at our disposal an opportunity of carrying out some investigations on the comparative electrical resistance of a number of pure metals, alloys, and non-metals at the low temperatures obtainable by the evaporation of liquid oxygen at ordinary barometric pressures and the ebullition of liquid oxygen under reduced pressures of about 25 or 30 millim. Since liquid oxygen, as already pointed out by one of us, is a very perfect insulating fluid, it is quite a simple matter, if once sufficient of the liquid gas is obtained, to measure the electrical resistance of a wire or small rod of the metal when immersed in liquid oxygen, and thus entirely at the same temperature as the evaporating liquid. A series of observations has accordingly been made by us on the specific electrical resistances of various metals, non-metals, and alloys over a range of temperature varying from + 100°C. to nearly – 200°C., and although these investigations are as yet incomplete, the observations already made seem to be of sufficient interest to render it worth while to place them on record.

A number of small resistance coils were prepared of wires of different metals and alloys in the following way. A thin rectangular sheet of mica about 5 centim. long and 1 or 2 centim. in width, had a number of nicks cut in the edges, and round this was wound loosely the wire whose resistance was to be determined. The ends of the wire were brought out through two holes in the mica and soldered to two stout copper terminal wires formed of high-conductivity copper wire well insulated with india-rubber. The ends of these terminal wires were bent over so as to dip into mercury cups. The small resistance-coil so formed could then be lowered into a test-tube full of the liquid gas or other fluid, by means of which the temperature of the wire was determined. The majority of the wires used had a length of 50 or 100 centim. and a diameter of ·003 of an inch (3 mils). The electrical resistance of these

* From the *Philosophical Magazine*.

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small coils of wire was measured by a Wheatstone's bridge, kindly lent for the purpose by Messrs. Elliott Bros. The coils of this bridge were of platinum silver, and adjusted to read in B. A. units at 15°·5 Cent. The balance was determined by the use of a highly sensitive mirror-galvanometer, using the current from a single Helsen's dry cell. The experiments were carried out in the Royal Institution laboratories, in a room which remained approximately at about 20°C. during the whole time. A series of wires of pure metals was obtained, and also others of known alloys. Mr. J. S. Sellon and Mr. G. Matthey, of Messrs. Johnson and Matthey, of Hatton Garden, kindly provided for us carefully drawn wires of absolutely pure annealed platinum, pure gold (999·9 degrees of fineness), pure silver, aluminium, and tin. Also wires of alloys of platinum silver, iridium platinum, rhodium platinum, palladium silver, as well as wires of palladium, and of nickel. From the London Electric Wire Company was procured some electrolytic copper wire of the highest conductivity obtainable, and also from Messrs. Griffin and Co. some pure annealed iron wire. Other wires of commercial materials, *e.g.*, German silver, platinoid, tinned copper, tinned iron wire, and commercial tin, were also mounted. The mean diameter of all these wires was measured with the microscope-micrometer to the nearest ten-thousandth of an inch, and the length also carefully ascertained. The electrical resistance of each of these small resistance-coils was then taken at six or seven fixed temperatures, as follows:—

1. At about 100°C. when immersed in a paraffin-oil or glycerine bath heated with boiling water.

2. At about 20°C. when immersed in a paraffin or alcohol bath at normal temperatures.

3. At about 0°C. when in a paraffin oil or alcohol bath cooled by melting ice.

4. At − 80°C. when immersed in a bath of ether and solid carbonic acid.

5. At − 100°C. when immersed in a test-tube full of liquid ethylene boiling freely under atmospheric pressure.

6. At − 182°C. when immersed in a test-tube full of liquid oxygen boiling freely under atmospheric pressure.

7. At − 197°C. when immersed in a closed tube containing liquid oxygen boiling under a reduced pressure of about 25 or 30mm. of mercury.

In the case of the measurements in liquid oxygen and ethylene, the liquid gases were contained in double test-tubes holding about 200 cub. centim., which were kept filled up as fast as the liquid boiled away, in order that the resistance-coil might always be fully covered. Each measurement of resistance was repeated several times. We thus obtained a mean *observed resistance*, which is the mean resistance as measured on the bridge. This had then to be corrected by deducting the resistance of the leads up to and including that of the mercury cups in which the resistance coil terminals were dipped. This correction was found to be equal to 0·025 B. A. units at 20°C. The *corrected resistance* is the resistance of the coil after this deduction. A further correction was then applied for the temperature of the Bridge coils, which were used at a temperature of about 1°9·5 C., or 4°C. above the temperature at which they were correct; and also a reduction to true ohms, effected by the use of the factor 0·9866 recommended by the Board of Trade Electrical Committee (1 B. A. unit = 0·9866 true ohm).

If R is the *corrected resistance* in B. A. units of any coil of wire, the length of which is l centimetres and the mean diameter d mils (1 mil = 0·001 inch), and if ρ is the resistance of one cubic centimetre of the metal between opposed faces, in absolute electro-magnetic units, then it was found that ρ and R were related by the equation

$$\rho = 5000 \frac{d^2}{l} R;$$

in which the numerical constant embodies all the above corrections. In this reduction no correction has been applied for the charge in volume which the wire undergoes when raised or lowered in temperature. Hence the values of ρ thus obtained for various temperatures are not the true equi-volume specific resistances, or resistances across opposed faces of one true centimetre of the metal whatever its temperature; but the values of ρ are the relative resistances at the different temperatures of one cubic centimetre of the metal taken at the atmospheric temperature and allowed to shrink or expand with the temperature. They are, therefore, the relative specific resistances for constant mass and not for constant volume. These latter cannot be obtained until we know the true mean coefficient of cubical or linear expansion of the various metals and alloys between 0°C. and − 100°C. and − 200°C.; but in any case, even for the most expansible metal, the correction would probably not amount to one-half of a per cent., or to less than the error created in the measurement of the resistance by an uncertainty in the temperature to the extent of 1°C.

The following tables give these specific resistances for constant mass (ρ) at the various temperatures ($t°$) of the different pure metals, alloys, and impure metals employed. The mean value of the various results is given, and the temperature in degrees Centigrade placed over the number denoting the specific resistance in absolute electromagnetic units. If these specific resistances are plotted out in a series of curves (*see* Fig. 1*), taking the *absolute temperature* as abscissæ, we find that all the lines of resistance are more or less curved lines which tend downwards in such a way as to show that if prolonged beyond − 200°C. they would probably pass through or near the origin or absolute zero. These curves of resistance can be divided into three classes:—(i.) Those of metals such as iron, nickel, tin, and perhaps copper, which are concave upwards; (ii.) those of metals such as gold, platinum, and palladium, and probably silver, which are concave downwards towards the axis of temperature; and (iii.) those of metals such as aluminium, which are apparently nearly straight

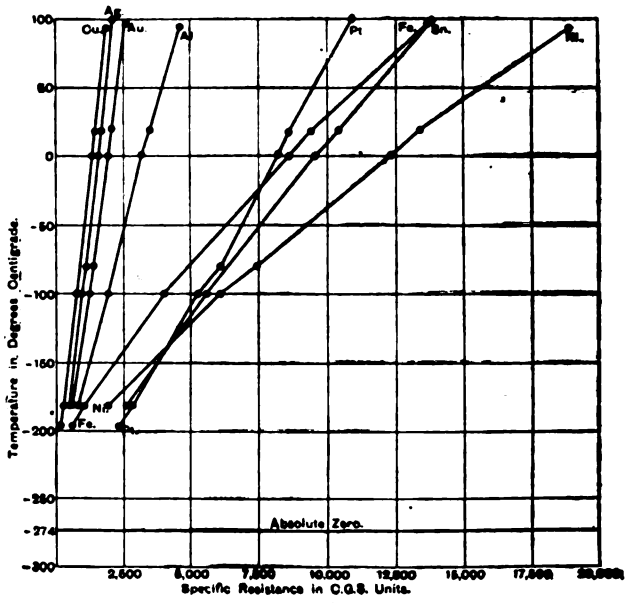

FIG. 1.

lines. In the case of a metal of the first class, such as iron, the resistance changes with the temperature in such a way that the rate of change of resistance with temperature *increases* as the temperature increases. In other words, the second differential of resistance with respect to temperature is *positive*. In the case of a metal of the second class, such as platinum, the second differential of resistance with temperature is *negative*—that is, as the temperature increases the rate of change of resistance with temperature *decreases*. This distinction between such metals as platinum and nickel, in respect of their variation of resistance with temperature, has been noted by Prof. Cargill G. Knott (*Proc.* Roy. Soc. Edin., Vol. XXXIII., 1888, p. 187), in a memoir on the Electrical Resistance of Nickel at High Temperatures. Prof. Knott's observations on the resistance of nickel were made between 0° and 300°C. Our own were between + 100° and − 200°C. Accordingly the distinction between these two

[* Pending the publication of curves by the authors we have taken the liberty of plotting out their observations. After the blocks were engraved we noticed that the authors refer to temperatures as abscissæ.—ED. *E.*]

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Table I.—*Specific Resistance* (ρ) *in Electromagnetic Units of various Pure Metals at different Temperatures.*

—	—	Temp. of boiling water.	Temp. of air.	Temp. of melting ice.	Temp. of melting carbonic acid.	Temp. of boiling ethylene.	Temp. of boiling oxygen.	Temp. of oxygen boiling *in vacuo*.	Remarks.
Platinum.	$t°$ C. =	100°·2	18°	1°	−80°	−100°	−182°	−197°	Pure annealed soft platinum wire.
	ρ =	10912	8698	8248	6133	5295	2821	2290	
Gold.	$t°$ C. =	96°·5	22°·3	0°·6	−80°	−100°	−182°	...	Purest soft gold wire.
	ρ =	2639	2096	1952	1400	1207	604	...	
Silver.	$t°$ C. =	100°	19°	0°·5	−80°	−100°	−182°	..	Pure silver wire.
	ρ =	2139	1643	1561	1138	962	472	...	
Copper.	$t°$ C. =	93°·2	18°·25	0°·7	...	−100°	−182°	−197°	Pure electrolytic copper, annealed.
	ρ =	1881	1447	1353	...	757	272	178	
Iron.	$t°$ C. =	96°·4	18°15	1°	...	−100°	−182°	−197°	Pure soft iron wire, annealed.
	ρ =	13777	9455	8659	...	4010	1067	608	
Aluminium.	$t°$ C. =	94°·5	19°·9	1°·5	...	−100°	−182°	...	Hard drawn pure aluminium wire.
	ρ =	4658	3503	3185	...	1928	894	...	
Nickel.	$t°$ C. =	94°·5	20°	1°·2	−80°	−100°	−182°	...	Pure nickel, prepared by Mr. Ludwig Mond's process from compound of mickel and carbonic oxide
	ρ =	18913	13494	12350	7470	6110	1900	...	
Tin.	$t°$ C. =	99°·3	20°	0°·8	−80°	−100°	−182°	...	Pure tin wire.
	ρ =	13837	10473	9609	6681	5671	2553	...	

Table II.—*Specific Resistance* (ρ) *of Various Alloys in Electromagnetic Units at Different Temperatures.*

—	—	Temp. of boiling water.	Temp. of air.	Temp. of melting ice.	Temp. of melting carbonic acid.	Temp. of boiling ethylene.	Temp. of boiling oxygen.	Remarks.
Platinum Silver. Ag = 66%, Pt = 33%.	$t°$ C. =	99°·3	18°·35	1°	−80°	−100°	−182°	The alloy commonly used for resistance coils.
	ρ =	27400	26905	26824	26311	26108	25537	
German Silver.	$t°$ C.	90°·3	18°·45	0°·8	−80°	−100°	−182°	Commercial wire.
	ρ =	35712	34688	34534	33664	33280	32512	
Platinoid.	$t°$ C. =	100°	18°·45	0°·88	−80°	−100°	−182°	Martino's Platinoid; German Silver, with 1 or 2 % of Tungsten.
	ρ =	44590	43806	43610	43022	42385	41454	
Palladium Silver. Pd = 20%, Ag = 80%.	$t°$ C. =	99°·8	20°	0°·8	−80°	−100°	−182°	From Messrs. Johnson and Matthey.
	ρ =	15409	14984	14965	14482	14256	13797	
Phosphor Bronze.	$t°$ C. =	100°	18°·75	0°·8	−80°	−100°	−182°	Commercial wire.
	ρ =	9071	8581	8483	8054	7883	7371	
Platinum Iridium. Pt = 80%, Ir = 20%.	$t°$ C. =	100°	18°·8	0°·6	−80°	−100°	−182°	From Messrs. Johnson and Matthey.
	ρ =	31848	29870	29390	27504	26712	24440	
Platinum Rhodium. Pt = 90%, Rh = 10%.	$t°$ C. =	100°	18°·8	0°·8	−80°	−100°	−182°	From Messrs. Johnson and Matthey.
	ρ =	18417	14532	13719	10778	9834	7134	

Table III.—*Specific Resistance* (ρ) *of Carbon at Various Temperatures.*

—	—	Temp. of boiling water.	Temp. of air.	Temp. of melting ice.	Temp. of melting carbonic acid.	Temp. of boiling ethylene.	Temp. of boiling oxygen.
Carbon from an Edison Swan incandescent lamp, No. 1.	$t°$ C. =	...	18°·9	1°	−80°	−100°	−182°
	ρ =	...	4049×10^3	4090×10^3	4189×10^3	4218×10^3	4321×10^3
Carbon from an Edison-Swan incandescent lamp, No. 2.	$t°$ C. =	99°	18°·9	1°	−80°	−100°	−182°
	ρ =	3835×10^3	3911×10^3	3953×10^3	4054×10^3	4079×10^3	4180×10^3
Carbon (Adamantine) from a Woodhouse and Rawson incandescent lamp.	$t°$ C. =	100°	18°·9	0°·8	−80°	−100°	...
	ρ =	6168×10^3	6303×10^3	6360×10^3	6495×10^3	6533×10^3	

metals, in this respect, extends over a very large range of temperature.

The most interesting fact which these experiments have brought out is the enormous decrease in specific resistance experienced by the *perfectly pure* metals when cooled to these low temperatures. Thus the electrical resistance of a given pure iron wire at −197°C. is only one twenty-third part of that which it is at + 100°C. In the case of pure copper the ratio of resistance is about one to eleven for the same change of temperature. The very smallest impurity greatly affects this decrease. In the case of some nickel wire supposed to be pure we found that the specific resistance at zero Centigrade was 13387 electromagnetic units, and that the specific resistance at − 182°C. was 6737. On repeating the measurement, however, with some absolutely pure nickel, obtained by Mr. Ludwig Mond's process of depositing the metal on glass by heating the gaseous compound of nickel and carbonic oxide, we found a very different result. In this

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last case, although the specific resistance at zero Centigrade was not very different, viz., about 12000 units, the specific resistance at – 182°C. was only 1900, showing a far greater decrease. For the perfectly pure metals, therefore, it seems probable that as the temperature is lowered towards the absolute zero the specific electrical resistance decreases so that it either vanishes at the absolute zero or reaches a very small residual value. Clausius made the suggestion in 1858 (Pogg. *Ann.*, Vol. CIV., p. 650) that the electrical resistance of all pure metals is proportional to the absolute temperature. Owing to the marked curvature of the resistance temperature lines this statement is only very approximately true for a few metals, and not at all for others, but it yet remains not improbable that the electrical resistance of all pure metals would at the absolute zero be either null or exceedingly small.

In the course of our experiments we found that the trend of the curve of specific resistance drawn with absolute temperatures as abscissæ seemed to give a very good indication of the chemical purity of the metal. If that curve tended downward so as to indicate that if prolonged it would probably pass through the absolute zero, the metal was indicated as pure. If, however, as in the case of the palladium wire and the first nickel wire used, it did not so tend, then impurity was probably in some way present.

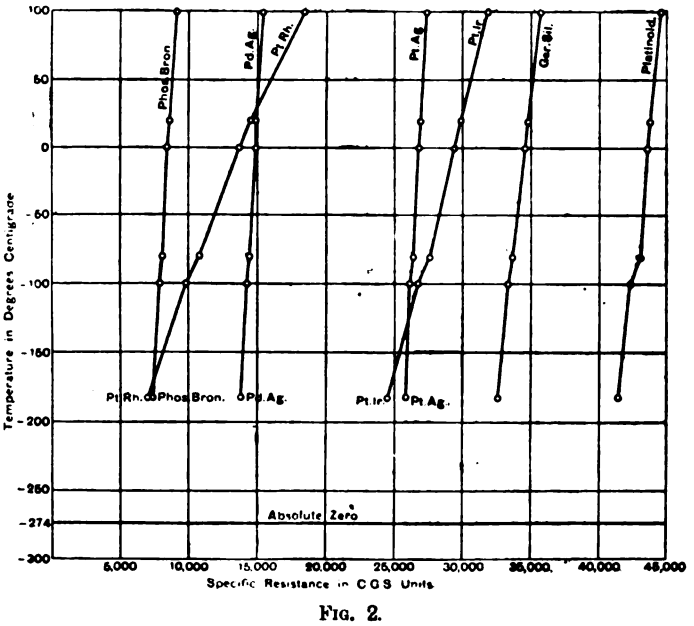

FIG. 2.

We next directed our attention to alloys, and Table II. is a table of the results obtained for them, treated in the same manner as regards temperature:—

On charting (*see* Fig. 2) the above figures for the alloys, it is found that the resistance-lines are very nearly straight lines with but little slope, not one-tenth that of the pure metals, when the constituent metals of the alloy are chemically very different. This is the case with the platinum silver, platinoid, and German silver alloys. When, however, the constituents of the alloy are chemically similar, as in the case of the platinum iridium and platinum rhodium alloys, the resistance-lines plotted in terms of the absolute temperature slope down at a much steeper angle, but never, as in the case of the pure metals, in such manner as to indicate that if prolonged they would pass through the absolute zero. In a similar manner the impure metals also behave. We have laid down on such a resistance-temperature diagram the lines representing the change of specific resistance with temperature for palladium not known to be pure, for nickel not pure, for commercial iron wire, for ordinary bismuth, for gold not pure, and other commercial metals, and found that the resistance-lines of these metals do not slope down at such an angle as to indicate that if prolonged they would pass through or near the origin or absolute zero. The lines for these impure metals are in position more or less like the lines for alloys formed of similar metals.

Another fact of considerable interest has been ascertained. We know that for temperatures above zero Centigrade, carbon behaves like an electrolyte as regards change of resistance with temperature, that is, its specific resistance *decreases* as temperature increases. Hence, it was a matter of importance to examine the behaviour of carbon as regards electric resistance when cooled to – 182° in liquid oxygen. For this purpose we employed the carbon filaments of incandescence lamps, taking the *treated* filaments of Edison-Swan lamps and the dense adamantine carbon employed in the Woodhouse and Rawson incandescence lamp. In both cases we found that when cooled to this low temperature the specific resistance of the carbon continuously *increased* (*see* Fig. 3) instead of decreasing, as do the metals. Table III. gives the specific resistance (ρ) in electromagnetic units of these carbons at various temperatures.

We have not yet completed the examination at similar low temperatures which we propose to make of the behaviour in regard to electrical resistance of such non-metals as selenium and sulphur, and such metals as arsenic and antimony, with marked chemical affinities with non-metals. Also the behaviour of such insulators as mica, glass, gutta-percha, india-rubber remains to be examined. It is known that the electrical resistance of these bodies decreases with rise of temperature. It is not improbable that we may find for such bodies a maximum electrical resistance at the lowest attainable tem-

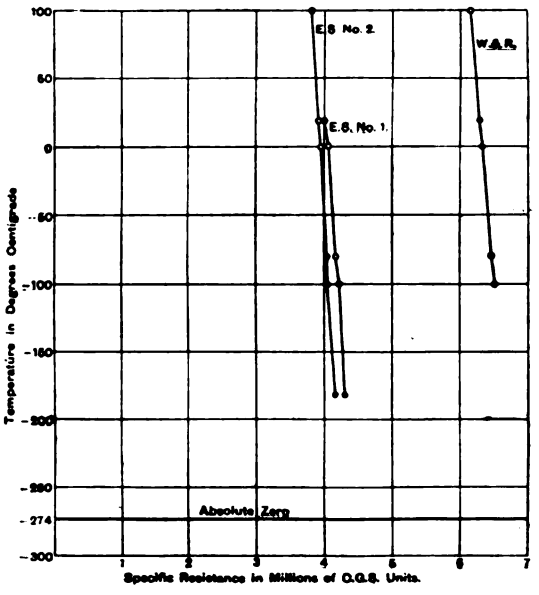

FIG. 3.

peratures, and that it may prove to be the case that pure non-metals approach a *maximum* specific electrical resistance and pure metals a *minimum* specific electrical resistance in proportion as the absolute zero of temperature is approached. In any case it is a matter of considerable interest to complete the examination of the change of conductivity with diminished temperature for all the metals in a state of the greatest chemical purity. MM. Cailletet and Bouty expressed the results of their experiments on the electrical resistance of metals between zero Centigrade and – 100°C. by giving the value of mean coefficient of resistance-change as follows:—If R_t is the electrical resistance of the metal at t°C., and R_0 its resistance at 0°C., then we may write

$$R = R_0(1 \pm \alpha t).$$

When t is in the neighbourhood of – 100°C., α has the following values, stated below, for the different metals. We give in one column the results of the experiments of MM. Cailletet and Bouty, and in the other coefficients for the same temperature range calculated from a part of our results in Table I.

From the values of the coefficients in Table IV. it is seen that nickel and iron have pre-eminence in respect of rate of fall of resistance with temperature. At ordinary temperatures pure iron has a specific electrical resistance of about seven times that of pure copper, and pure nickel has about ten times the resistance; but at the temperature of liquid oxygen boiling at

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ordinary atmospheric pressure, the specific resistance of iron is only two-thirds of that of pure copper at the ordinary temperature, whilst that of nickel is only about twice as great as that of iron. It is a striking illustration of the effect of great cold on electrical conductivity to realise that at the temperature of boiling liquid oxygen pure iron conducts electricity better than the purest electrolytic copper does at ordinary temperatures. We hope before long to extend and complete the above investigation.

Table IV.

Metal.	α = mean coefficient of resistance-change between 0° and −100°C.	
	Cailletet and Bouty.	Dewar and Fleming.
Silver	0·00385	0·00384
Aluminium	0·00388	0·00390
Copper	0·00423	0·00410
Iron	0·00490	0·00531
Platinum	0·00340	0·00354
Tin	0·00424	0·00509
Magnesium	0·00390	..
Mercury	0·00407	...
Nickel	...	0·00500

THE EFFICIENCY OF TRANSFORMERS AT DIFFERENT FREQUENCIES.*

BY PROF. W. E. AYRTON, F.R.S. AND W. E. SUMPNER, D.SC.

Some years ago Mr. Mordey published in the *Journal* of the Institution of Electrical Engineers the results of some experiments which appeared to show that, when a transformer of the Mordey type of construction was working at a given load, the waste of power was less at a frequency of 100 than at a higher or lower frequency. In 1888, to test this point, experiments were carried out at the Central Institution by Messrs. Lamb, Smith, and Woods, the power put into and taken out of a Mordey type of transformer being measured by the electrometer method, and it was for the purpose of these tests that there was constructed the large non-inductive resistance that was described by Mr. Mather and one of us before the Physical Society last year.

But, although this method is theoretically one of the best for ascertaining the power given by any current to any circuit, the percentage error in measuring the efficiency is, of course, the percentage error in measuring the power put into or taken out of the transformer. And as it is very difficult to avoid making errors of 1 or 2 per cent. with the electrometer method, it is almost impossible to be sure of changes of this magnitude in the efficiency produced by a variation in the frequency. Subsequently tests were made by others of the students, employing other methods for measuring the power, but it was not until one of us had devised the method that appeared this year in the technical press for measuring *directly* the losses in a transformer that we felt in a position to express an opinion regarding the actual effect produced by variation of frequency on the efficiency of a transformer.

Except under special circumstances, to be subsequently referred to, this method requires, for its employment, two transformers similar in type and output, and a third transformer, which may be of much smaller output, for supplying the energy lost in the coils of the two large transformers. The detailed working of the method will be understood on reference to Fig. 1. The fine wire coils of the two transformers A, B are connected in parallel through the high pressure switches *s*, *s*. The thick coil of A is connected directly with the mains, while the thick coil of B has one of its ends joined with one of the mains, and the other in series with a dynamometer D, a switch S_2, the current coil of the wattmeter W_1, the secondary of the subsidiary transformers C, and finally with the other main load. A switch S_1 is placed in one of the mains, as indicated in the figure, so that the current supplied directly from the mains can be switched off when desired. The primary of transformer C is connected with the mains through an adjustable resistance R_3 and a switch S_3. A wattmeter W_2 has its current coil joined up so as to be traversed by the current entering the parallel circuit formed by the primaries of A and B, and its pressure coil placed in series with the non-inductive resistance R_2 across the mains. The pressure coil of the other wattmeter W_1 is connected in series with the non-inductive resistance R_1 across the secondary of the auxiliary transformer C.

If the switches S_1, S_2, be closed the currents flowing are merely the magnetising currents required for the transformers A and B, and W_2 merely measure the open circuit losses. Unless the secondary of C be short circuited no current will flow through the thick coil of B, for the magnetising current is then supplied by the thin coil after transformation by A. If now switch S_3 be closed, so that the secondary of C supplies a potential difference of, say, 6 volts to the circuit forced by the thick coils of A and B, large currents will flow through the transformers. The potential difference between the terminals of A will be, of course, the voltage of the mains, for example 100, but the potential difference at the terminals of B will be either 106 volts or 94 volts, according as the six volts supplied by the secondary

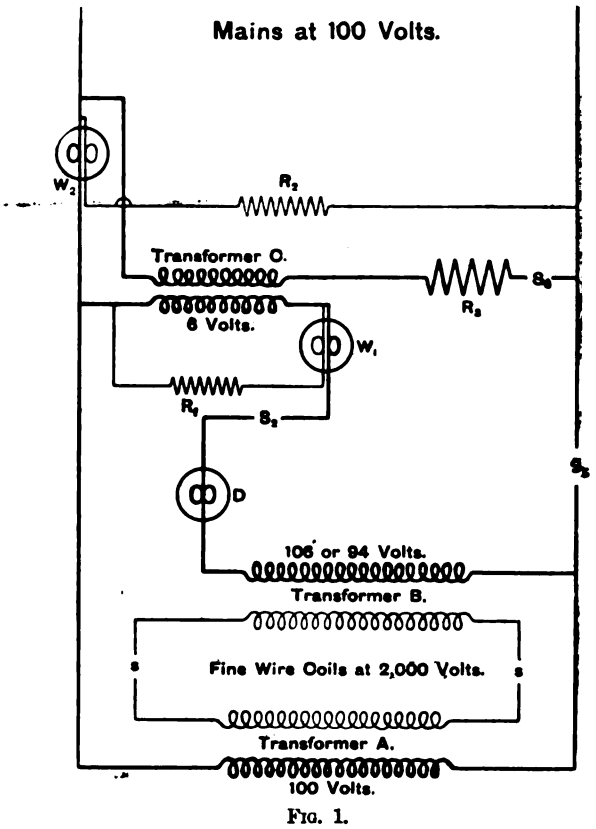

FIG. 1.

of C are in opposite phase, or in the same phase, as the 100 volts between the mains. (Indeed, if there were considerable magnetic leakage in the transformer C, or if R_3 were a highly inductive resistance, the potential difference of the six volts supplied by C would be out of phase with the voltage on the mains, and the potential difference at the terminals of B might be anything between 106 and 94 volts.) If there be a potential difference of 106 volts between the terminals of B, this transformer is being used as a step-up transformer, and A is converting downwards. If, however, there be only 96 volts between the terminals of B, it is A which is working as the step-up transformer, and B which is converting downwards. In the majority of the cases to be subsequently described the six volts supplied by C were sufficient to drive the full load currents through the transformers.

The load, W, we take as being measured by the product of the current indicated by D, and the potential difference supplied to the primary of the step-up transformer. If A is used for converting upwards, this load is simply 100 times the current in amperes, whereas if B is used as the step-up transformer the

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power returned to the mains by A is 100 times the current in amperes, and if to this we add the two power losses measured by W_1 and W_2, we obtain the power taken from the mains and supplied to the primary of B. If w be the load in watts supplied to the step-up transformer; if w_1 and w_2 be the watts at this load measures by W_1 and W_2 respectively; and if λ be at the same time the loss of power in the leads used in joining up the transformers, in the coils of the dynamometer D and in the current coil of W_1, the total loss in the two transformers is

$$w = w_1 + w_2 - \lambda,$$

and the efficiency of the double conversion is

$$\eta = 1 - \frac{w}{W}.$$

The advantage of this method of determining efficiency, as pointed out some years ago by Dr. Hopkinson in connection with a similar method of measuring the efficiency of dynamos and motors, is that a small error in determining either w or W will make practically no difference in the calculated value of η. For instance, as the value of η for *two* transformers is about 90 per cent., w is about one-tenth part of W, and it follows that an error of *10 per cent.* in estimating the ratio w/W only affects η to *1 per cent.*, and only affects the calculated efficiency of each transformer to *one-half per cent.*

It would have been more accurate had we placed the dynamometer D in circuit with the thick coil of A rather than with the thick coil of B, but the currents in the coils of A and B for closed magnetic circuit transformers differ to such a slight extent that either current may be approximately taken to represent the load without introducing any appreciable error in the determination of the efficiency.

The instruments used were of a rough character, and no special care was taken with them; for our object was rather to see how far measurements made by this method with common instruments could be relied upon, than to obtain the most accurate results possible.

D (*see* Fig. 1) is an ordinary Siemens dynamometer measuring up to 55 amperes for one revolution of the pointer when the thick coil is in circuit.

W_2 is a Ganz wattmeter, supplied, as usual, with two non-inductive resistances. In the following experiments its sensibility was such that one revolution of the pointer corresponds with about 1,200 watts.

W_1 is a Siemens dynamometer as made commercially but modified so as to form a wattmeter by connecting the mercury cups forming the ends of the movable coil with two separate terminals. This swinging coil was used, in series with a suitable non-inductive resistance R_2, as the pressure coil of the wattmeter, one of the fixed coils being traversed by the main current. When large currents were flowing through the thick coils of A and B a current of 8 or 10 amperes often passed through the *volt coil* of this wattmeter, and its attached resistance R_1; but although the power so wasted was quite appreciable, consideration of Fig. 1 will show that the reading of the wattmeter W_1 is not affected by it in the least, and that it thus does not enter into the calculation of the efficiency.

An ordinary Cardew voltmeter was used for the adjustment of the potential on the mains.

The transformers tested were:—

M_1, M_2. Two transformers of the Mordey type, each of output 4·5 kilowatts, converting from 2,000 volts to 100 volts (or 50 volts). They are numbered 1874 and 1872. We shall for brevity allude to them respectively as M_1 and M_2.

M_3. One transformer of the Mordey type of output 3 kilowatts, converting from 2,000 volts to 100 volts (or 50 volts). Its number is 1832, and in what follows it is alluded to as M_3.

M_4. One transformer of the Mordey type of output 1·5 kilowatts, converting from 100 volts to 100 volts. It has three coils each of the same number of turns, and occupying spaces proportional to the numbers 1, 1, and 2 respectively. The transformer was wound in this way for experimental purposes, but in other respects it does not differ in construction from the ordinary type made by the Brush Company in 1887. It is alluded to in the following experiments as M_4.

H. One Hedgehog transformer, made by Messrs. Swinburne and Co., of output 4 kilowatts, converting from 2,000 volts to 100 volts. It is referred to by the letter H.

A small transformer of change ratio 6 to 1 was occasionally used as the subsidiary transformer C. It was not, however, of any recognised commercial type and the magnitude of its efficiency does not enter into the tests.

The losses in the leads were carefully determined and confirmed by measurement made with different methods. The same leads and instruments were used in all the experiments. The first method of testing was to measure the resistances of the different coils and leads and calculate the losses at the currents used. These measurements were confirmed by passing steady currents of 30 and 40 amperes (measured by a standard d'Arsonval galvanometer used as an ammeter in shunt to a platinoid strip) through the leads and measuring with the aid of a standard voltmeter (a second d'Arsonval galvanometer used in series with known resistances) the power lost in the leads for these currents. The same experiment served to calibrate the dynamometer D. The wattmeters W_1 and W_2 had been previously calibrated by means of the same two standard instruments. The measurements were made when both the thin and the thick coils of the dynamometer D and the wattmeter W_1 were in circuit, since in the actual transformer tests it was occasionally found necessary to change these coils. The measurements of the losses in the instruments and leads were further confirmed by tests with *alternate currents* of the same frequencies as those used in the measurements; and it will be apparent that one of the advantages of the method of testing the efficiency of transformers which we have employed arises from the fact that the apparatus required for the efficiency measurements can be used for determining the losses in the leads, &c., *without any alteration of the connections*. For if the switch S_1 be open and switches S_2 and S_3 be closed and the primaries of the transformers A and B are short-circuited, the reading of the wattmeter W_1 will at once measure the losses occurring in the testing apparatus itself when any special current (measured by D) is passing though it.

The measurements made by these different methods were in quite satisfactory accordance with each other. With a current of 40 amperes the loss in the leads, when the thick coils of D and W_1 were used, was 55 watts. When the thin coil of D was substituted for the thick coil the extra loss at 40 amperes was 70 watts, and an equal increase in the loss was caused by using the thin coil of W_1 instead of the thick coil.

The losses occurring in the coils of the transformers can be measured independently of the other losses by simply leaving the switch S_1 open and taking the reading of W_1 for different alternating currents flowing through D. The two transformers A and B are so connected that a potential difference of a few volts will cause large currents to flow through the thick coils when the switches *s s* in the secondary circuit are closed. Of course the iron cores are magnetised slightly and a certain amount of energy is absorbed by hysteresis, but this is quite negligible compared with that lost in the copper. For, at most, the voltage corresponding with the induction of the core is only that needed for driving the currents through the resistance of the transformer coils. This is only about 1 per cent. of the ordinary voltage of the transformers and as the losses in the iron vary as the square of the induction density (more accurately as $B^{1\cdot6}$), the core losses are only $0\cdot01 \times 0\cdot01$, *i.e.*, 0·0001 of the normal losses occurring in the use of the transformer.

It thus becomes possible to investigate the very important matter of the variation of the core losses under different conditions of load. All that need be done is to determine:—

(1.) The total losses occurring in core, coils, and testing apparatus for different currents when S_1 is closed; and

(2.) The total losses in the coils and testing apparatus for the same currents when S_1 is open. The difference between the losses found for any particular current is the loss in the core for that particular load.

It was pointed out in the article in the technical press already referred to that the reading of W_2 practically gave the iron losses in the two transformers, and that W_1 gave the losses

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caused by the heating effect of the currents in the coils, &c. The measurements made with closed circuit transformers have entirely confirmed this view.

Thus for the two 4½ kilowatt transformers of the Mordey type (M_1 and M_2), tested at 100 volts and a frequency of 160, the reading of W_2 gradually changed from 220 watts on open circuit to 230 watts at a load of 2,500 watts, and to 235 watts at a load of 5,000 watts, whereas the core losses as determined by the subtraction method were 220 watts on open circuit, 220 watts at a load of 2,500 watts, and 227 watts at a load of 5,000 watts, or practically the same as the watts as measured by W_2. In another test at a frequency of 150 the reading of W_2 changed from 210 watts on open circuit to 222 watts at a load of 4,000 watts, the iron losses, as calculated by the difference method, diminishing gradually from 210 watts on open circuit to 200 watts at a load of 4,000 watts.

In another test at the same frequency the reading of W_2 altered from 215 watts on open circuit to 210 watts at full load, while the iron losses were found exactly the same as the corresponding readings of W_2, up to a load of 3,000 watts; afterwards, however, the iron losses were slightly greater. In a test at a frequency of about 100 the reading of W_2 decreased from 260 watts to 250 watts as the load increased up to 4,000 watts, the iron losses being the same up to a load of 2,500 watts, and being slightly less afterwards and equal to 230 watts at a load of 4,000 watts. In a later test, at a frequency of 100, the reading of W_2 only changed from 285 watts to 290 watts from open circuit to a full load of 5,000 watts, while the iron losses diminished under the same circumstances from 285 watts to 275 watts.

In all these experiments numerous tests at intermediate loads were taken, and the general smoothness of the curves obtained by plotting the observations is such as to justify considerable confidence in the character of the results, the slight differences between the curves denoting the readings of W_2 and those representing the iron losses are sometimes in one direction and sometimes in the other, and are to be regarded as an indication of the extent of the experimental error to which the measurements are subject rather than as any certain evidence of alteration of the core losses with the load. In fact the experiments seem to show that, with closed circuit transformers at any rate, the core losses are practically constant at all loads. This conclusion is only what theory indicates, but it has frequently been doubted, as many published efficiency tests of transformers have indicated that the core losses diminish as the load increases.

This constancy of the iron losses is further evidenced by tests made with the other two Mordey transformers. Thus in testing the combination of the 4,000 watt Mordey (M_1) with the 3,000 watt Mordey (M_3) the iron loss at a frequency of 160 only altered from 185 watts at no load to 175 watts at a 4,200 watt load. In another test at a frequency of 200 the core losses changed from 170 watts at no load to 155 watts at a load of 4,200 watts. In a test of the 1,500 watt Mordey M_4 the iron losses at a frequency of 160 were found constant within 1 per cent. while the load changed from 0 to 3,000 watts or double full load.

When the open magnetic circuit transformer was used the measurements were not so satisfactory. Two or three reasons may be assigned for this. Owing to the large magnetising current the reading of the dynamometer D cannot be taken to indicate the current in the thick coil of A as well as that in the thick coil of B. Also owing to the great difference in the regulation of the Hedgehog transformer when converting up or down, the voltage on the transformer C had to be considerably greater than in the previous tests when the full load currents were flowing; and, consequently, while one of the transformers, A, B, is worked at the proper voltage, the other is worked at a voltage considerably different from 100. The curves obtained are sometimes of a curious character, and we have not yet had time to fully explain them. As we hope to repeat these tests, we prefer to postpone the publication of the results referring to the core losses of open circuit transformers. Our experiments, however, indicate that the iron losses do not alter by as much as 10 per cent. when the load is increased from 0 to full load.

Before summarising the results obtained it will be well to explain in detail the arithmetical working, by means of which the efficiency is obtained from a single set of measurements with the three instruments W_1, W_2, and D. When the two large Mordey transformers (M_1 and M_2) were being tested at a frequency of 107 it was observed that when the current as read by D was 44·8 amperes, W_1 indicated 310 watts, and W_2 indicated 290 watts. In this particular experiment M_1 was on the mains at 100 volts, and was used as a step-down transformer, the volts on the primary of M_2 being greater than 100 volts. While, therefore, $44{\cdot}8 \times 100$ watts were being returned to the mains by M_1, the thick coil of transformer M_2 was being supplied with $4{,}488 + 310 + 290$ watts. The load on the step-up transformer was thus 5,080 watts. The total loss in the two transformers is, however, less than 600 watts, since there is a considerable loss in the leads and dynamometers, &c. The loss in the leads at 44·8 amperes is 63 watts. The thin coil of W_1 was used in this particular test, so that an additional loss of 89 watts must be allowed for. No extra allowance has to be made for D, as the thick coil was used, and the loss in this coil is already taken into account in estimating the loss in the leads. The total loss in the testing apparatus for this current is therefore 152 watts, and the total loss in the transformers is thus $600 - 152 = 448$ watts. The joint efficiency at this load of 5,080 watts is therefore $1 - \frac{448}{5080} = 1 - {\cdot}0883 = 91{\cdot}18$ per cent. This number is the product of the efficiencies of the two

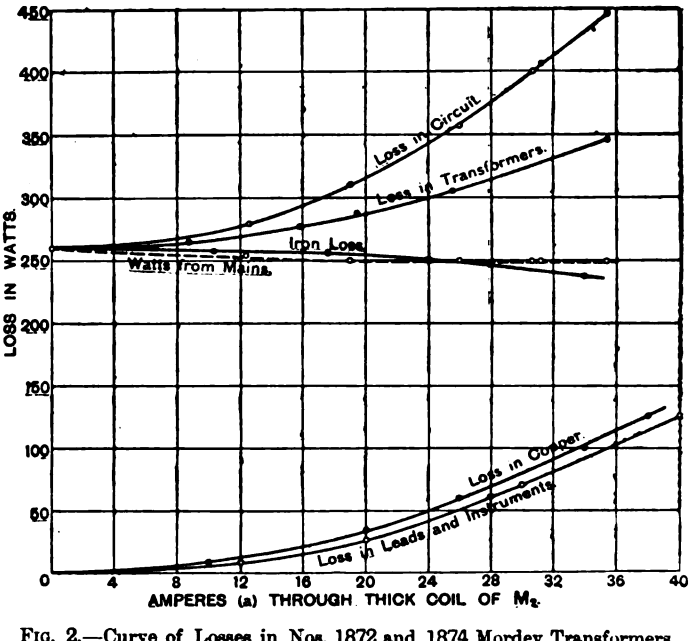

FIG. 2.—Curve of Losses in Nos. 1872 and 1874 Mordey Transformers. Primary Volts 100. Frequency 100. M_1 used as Step-down Transformer. M_2 used as Step-up Transformer. Load = 100a + Total Losses.

transformers, and, if these are assumed to be equal, the true efficiency is obtained by taking the square root of 0·9118, giving 95·5 per cent. Also if the copper losses at this current, determined by the method already described, be subtracted from the total loss of 448 watts, we obtain 275 watts as the iron losses at this load. This only differs by 15 watts from the actual reading of W_2.

This process has been gone through for each of the efficiency determinations made; but, in order to simplify the work, curves have been plotted denoting respectively the losses in the leads, in the transformer coils, the total losses in leads and transformers, the total losses in the transformers, the losses in the core, and the corresponding power supplied by the mains and measured by W_2.

The curves shown in Fig. 2 indicate a complete set of observations made on the two large Mordey transformers M_1 and M_2. As many as thirty such sets were taken in connection with different combinations of the transformers. Several of these had to be rejected from various causes. For instance, it was at first arranged, by means of a combination of switches, to make one wattmeter

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do the work of the instruments W_1 and W_2, but after several measurements had been taken it was found that the alteration of the resistance of the circuit caused by the introduction of the wattmeter coil altered the currents flowing to a serious extent. The majority of the tests, however, confirmed each other in a very satisfactory manner. It is unnecessary to give the details of all the measurements, and we shall, therefore, merely give the numbers denoting the losses at different loads. These losses are interpolated from the curves drawn through the actually plotted points. The following table shows the results obtained from five sets of observations at various frequencies on the two large transformers M_1 and M_2.

Combined losses in two 4½ kilowatt transformers of the Mordey type.

—	Approximate frequency in periods per second.		
	100	120	160
Load in watts.	Loss in watts in the two transformers.		
1,000	292	270	229
2,000	305	280	241
3,000	335	305	275
4,000	375	345	320
4,500	400	...	...
5,000	425	...	...

From these numbers we obtain the following values for the efficiency of each of these two transformers :—

—	Approximate frequency in periods per second.		
	100	120	160
Load in watts.	Efficiency of each transformer.		
1,000	84·46	86·59	88·58
2,000	92·19	92·76	93·84
3,000	94·27	94·79	95·30
4,000	95·22	95·60	95·91
4,500	95·46	...	...
5,000	95·76	...	...

From these numbers it follows :—

1st. That the greater the frequency the higher the efficiency for any particular load.

2nd. That the greater the load the higher the efficiency for the same frequency.

Both these results follow, of course, from the fact that the iron losses are the same at all loads for a given frequency and diminish as the frequency increases. And they do not, for these particular transformers at any rate, confirm the results referred to at the commencement of this Paper that the efficiency is a maximum at the frequency of 100.

The open circuit losses expressed as percentages of full load are 3·2 per cent., 2·8 per cent., and 2·36 per cent. at frequencies of 100, 120 and 160 periods per second. If the iron losses be constant for all loads at a given frequency it can easily be proved that the efficiency of a transformer must be a maximum when the copper losses become equal to the iron losses. And calculation shows that for these two 4½ kilowatt transformers of the Mordey type, this equality will occur at a load of 7,200 watts at a frequency of 100, at a load of 5,500 watts at a frequency of 160, and at a load of 5,000 watts at a frequency of 200 periods per second, when the maximum efficiencies become 96 per cent., 96·1 per cent., and 96·3 per cent. respectively. There is, therefore, no great difference between the maximum efficiencies at different frequencies, but the higher the frequency the lower the load at which the maximum efficiency occurs.

The following table summarises the results obtained from the tests of the 3,000 watt (M_3) and the 4,500 watt (M_1) transformers of the Mordey type combined :—

—	Frequency in periods per second.		
	107	160	200
Load in watts.	Loss in watts in the two transformers.		
0	235	185	175
3,000	320	265	255
4,000	410	340	365

From these numbers we obtain the following values for the *joint* efficiencies of these two transformers :—

—	Frequency in periods per second.		
	107	160	200
Load in watts.	Joint efficiency of the two transformers.		
3,000	89·33	91·17	91·50
4,000	89·75	91·50	90·88

Now from the former tests we know the efficiency of M_1 at these loads and at two of the frequencies. We can thus obtain, by division, the efficiency of M_3, as follows :—

—	Frequency in periods per second.	
	107	160
Load in watts.	Efficiency of transformer M_3.	
3,000	94·76	95·66
4,000	94·25	95·41

The efficiency of the small 1,500 watt transformer (M_4) of the Mordey type was tested at a frequency of 150, and found to be 90·2 per cent., at a load of 1,500 watts, and higher at a larger output. The method used in testing this transformer is of some interest, arising from the fact that, as already stated, this transformer was for special experimental reasons so wound that it transformed from 100 volts to 100 volts. Now, when the change ratio of a transformer is unity, it is not necessary to employ another similar transformer when using our method of testing the losses directly, since the primary and secondary coils can be employed—one to take energy from the mains and the other to give back what is not lost in the transformation. Of course, an auxiliary transformer (C, Fig. 1) must be employed, but the two transformers, A and B in the figure, are replaced by the single unity change-ratio transformer M_4.

As the large transformers of the Mordey type are wound with two thick wire coils in addition to the fine wire one in order that the transformers may, if required, be used on the three-wire system, it is possible to measure the efficiency by the method just described without the employment of a second transformer. And tests that we made in this way confirmed those previously carried out.

But, as the fine wire coil of the transformer is not used, this method, although excellent for a transformer whose change ratio is unity, is not to be recommended for one which transforms from 50 or 100 to 2,000 volts. Indeed, it is obvious that if the test be made in the way just described the advantage of dispensing with the duplicate transformer is counterbalanced by the fact that the transformer tested can only be used at what is practically half load, and the copper losses are therefore proportionately greater than when the transformer is used in the ordinary way at full load. Employing, therefore, two similar transformers as well as a small auxiliary transformer as in Fig. 1, is much to be preferred.

A large number of tests were made by combining the Hedgehog transformer H_1 with M_1 and with M_3, and, although the results (as already mentioned) were not as satisfactory as when two Mordey type of transformer were employed, they were sufficiently accurate to show that neither at no load nor at full load is there any great difference apparently between the power wasted in a Hedgehog and in a Mordey type of

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transformer of the same output. On this point, however, we shall say more when we have had more time to analyse the results we have already obtained with the Hedgehog transformer.

In conclusion, we wish to express our thanks to the Brush Company for so kindly lending us the two 4½ kilowatt transformers, and also our obligations to several students at the Central Institution, and more especially to Messrs. Baillie, Baylay and Clift, for their interest and energy in carrying out the experiments, and in reducing the results.

PROPAGATION OF THE CURRENT IN A CABLE CONTAINING DISTRIBUTED STATIC CAPACITY AND SELF-INDUCTION.*

BY FREDERICK BEDELL, PH.D., AND ALBERT C. CREHORE, PH.D.

The problem of the propagation of the electric current in a cable containing distributed static capacity was first discussed by Sir William Thomson, and afterwards by Mascart and Joubert,† Blakesley,‡ and others. The solution for the variation in the current and potential at different points of a conductor containing self-induction, as well as distributed capacity, has recently been given by the writers in the *American Journal of Science*,§ and some of the effects of the self-induction noted.

It is here intended to give a fuller treatment of the problem, and to discuss the nature of the wave propagation in such circuits.

Fig. 1 represents the longitudinal section of a cable, A being the conducting wire, and B B the insulating sheath which surrounds it. Let us suppose that this cable is submersed in

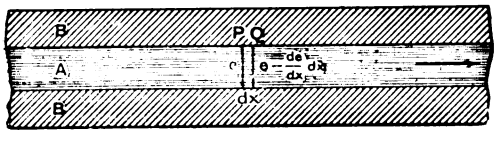

FIG. 1.—Longitudinal Section of Cable.

water, which forms the other conductor and plate of the condenser. If the capacity of a unit length be denoted by C, the capacity of the element P Q, whose length is dx, is C dx. Let R denote the resistance per unit length of the conductor, and Rdx the resistance of an element. Suppose a current i is flowing at P, in the positive direction, as indicated by the arrow. Let the potential of P at that instant be denoted by e. Since the current always flows from the higher to the lower potential, the potential of Q, the other end of the element, must be less than at P; and the potential, therefore, diminishes in the positive direction. This fall in potential between P and Q is denoted by $-\frac{de}{dx}dx$. By Ohm's law the current i, at any moment through the element P Q, equals the difference in potential divided by the resistance, and is, therefore,

$$i = -\frac{\frac{de}{dx}dx}{R\,dx} = -\frac{1}{R}\frac{de}{dx}. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If the current remained constant, having this value i all the time, the potential of the element and its charge would continually remain the same, and the flow of electricity across the section Q would be the same as that at P, since as much must flow out from as into the element, unless the charge of the element be changed. Now considering that the current does not remain constant, but changes every moment of time, the potential e, of the element and consequently its charge, must change with the time. When the charge changes, it means that more electricity is flowing into than out from the element, or *vice versa*, and consequently the flow of current across P is different from that across Q, by just such amount as the element gains or loses. The current at Q is then denoted by

$$i + \frac{di}{dx}dx.$$

Let the quantity flowing across the section P, in the time dt, be denoted by dQ, and that flowing across the section Q, by $dQ - dq$, where dq is the change in the charge of the element in the time dt. The quantity of electricity flowing across the section P is equal to the current flowing at P multiplied by the time, that is,

$$dQ = i\,dt, \text{ or } i = \frac{dQ}{dt}. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Similarly the flow across Q is the current flowing at Q multiplied by the time; that is,

$$dQ - dq = \left(i + \frac{di}{dx}dx\right)dt. \quad . \quad . \quad . \quad (3)$$

Subtracting (3) from (2), we obtain—

$$\frac{dq}{dt} = -\frac{di}{dx}dx. \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This equation may be interpreted to mean that the rate of change of the charge on the element is equal to the difference of the currents flowing into the element and out from it. We might at once have written the equation from this consideration.

The charge of the element, as of any condenser, is equal to its capacity multiplied by its potential. The charge being denoted by q, the potential by e, and the capacity, as stated above, by C dx, we have,

$$q = C\,e\,dx. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The rate of change of the charge with the time is, by differentiation,

$$\frac{dq}{dt} = C\frac{de}{dt}dx. \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Equating this result to equation (4), we have

$$-\frac{di}{dx} = C\frac{de}{dt}. \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Equations (1) and (7) are the differential equations which are sufficient to determine the problem of the propagation of the current in a cable with distributed capacity when the impressed E.M.F. of the source is known. The solutions of these equations may be obtained for the most general case, although the arbitrary constants of integration can only be determined in certain particular cases where the impressed E.M.F. is known. When the impressed E.M.F. is harmonic and equal to $e = E \sin \omega t$, the arbitrary constants may be found.

These two differential equations may be expressed as a single equation by differentiating (1), with regard to x, and equating to (7); thus,

$$\frac{di}{dx} = -\frac{1}{R}\frac{d^2e}{dx^2}, \quad \text{and, therefore,}$$

$$\frac{d^2e}{dx^2} = C\,R\frac{de}{dt}. \quad . \quad . \quad . \quad . \quad . \quad (8\frac{1}{2})$$

In the foregoing discussion no account has been taken of the self-induction of the circuit, but it necessarily has a certain effect upon the flow of the current, which we will now consider. The effect of self-induction must be felt as a back E.M.F. opposing the current and depending upon its rate of change. We shall assume that this back E.M.F. per unit length of the conductor is equal to the rate of change of the current, multiplied by a constant; that is, it is equal to $L\frac{di}{dt}$. In some cases this assumption may approximately represent the true effect of self-induction, and it is thought that this particular assumption may show the nature of the effect of self-induction even in cases where this assumption is not justifiable. Instead of leaving equation (1) as it stands, therefore, without taking into account the effect of the back E.M.F. of self-induction, we may introduce this effect into the

* From a forthcoming work on "Alternating Currents." (The W. J. Johnston Co., New York.) All rights reserved.

† Mascart and Joubert, "L'Électricité et Le Magnétisme, Vol. I., Section 233.

‡ T. H. Blakesley, "Alternating Currents of Electricity," Chap. viii.

§ Drs. Bedell and Crehore, *American Journal of Science*, October, 1892.

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equation by subtracting from the difference of potential between P and Q, viz, $\frac{de}{dx}$, the internal E.M.F. of self-induction, $L\frac{di}{dt}dx$, and so may write,* still in accordance with Ohm's Law,

$$i=\frac{\left(\frac{de}{dx}dx-L\frac{di}{dt}dx\right)}{R\,dx}=-\frac{1}{R}\frac{de}{dx}+\frac{L}{R}\frac{di}{dt}. \quad . \quad (8)$$

The relation in equation (7) is not changed by the consideration of the self-induction, and these two equations (7) and (8) are sufficient to determine the problem of the flow of current, taking into account both the capacity and the self-induction. These equations, now containing four variables, may be expressed as two differential equations containing three variables by eliminating first i and then e. After transposing and arranging, we may write (7) and (8).

$$C\frac{de}{dt}+\frac{di}{dx}=0. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$\frac{de}{dx}-L\frac{di}{dt}+Ri=0 \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Operating upon (9) by $\frac{d}{dt}$, that is differentiating with respect to t, we obtain

$$C\frac{d^2e}{dt^2}+\frac{d\left(\frac{di}{dx}\right)}{dt}=0. \quad . \quad . \quad . \quad . \quad (11)$$

Operating upon (10) by $\frac{1}{L}\frac{d}{dx}$, we find,

$$\frac{1}{L}\frac{d^2e}{dx^2}-\frac{d\left(\frac{di}{dt}\right)}{dx}+\frac{R}{L}\frac{di}{dx}=0. \quad . \quad . \quad . \quad (12)$$

Adding (11) and (12), we have

$$C\frac{d^2e}{dt^2}+\frac{1}{L}\frac{d^2e}{dx^2}+\frac{R}{L}\frac{di}{dx}=0. \quad . \quad . \quad . \quad (13)$$

Substituting here the value of $\frac{di}{dx}$ in (9), namely, $-C\frac{de}{dt}$, we eliminate i and finally have for the differential equation of the potential

$$\frac{d^2e}{dx^2}+LC\frac{d^2e}{dt^2}-RC\frac{de}{dt}=0. \quad . \quad . \quad . \quad (14)$$

To eliminate e from (9) and (10), operate upon (9) by $\frac{d}{dx}$, and upon (10) by $C\frac{d}{dt}$, and we have

$$C\frac{d\left(\frac{de}{dt}\right)}{dx}+\frac{d^2i}{dx^2}+\frac{d^2i}{dx^2}=0, \quad . \quad . \quad (15)$$

and

$$C\frac{d\left(\frac{de}{dx}\right)}{dt}-LC\frac{d^2i}{dt^2}+RC\frac{di}{dt}=0. \quad . \quad . \quad . \quad (16)$$

Subtracting (16) from (15), we have the differential equation for current.

$$\frac{d^2i}{dx^2}+LC\frac{d^2i}{dt^2}-RC\frac{di}{dt}=0. \quad . \quad . \quad . \quad (17)$$

It is evident from the similarity of the equations (14 and 17) that the integral current equation will be the same as the integral potential equation, except for the arbitrary constants that enter in integration. The general solutions of these equations are:—

$$e=\sum_{h,k}hk\epsilon^{\frac{R(t-ckx)}{ck^2+L}};$$

$$i=\sum h\epsilon^{\frac{R(t-ckx)}{ck^2+L}}.$$

where ϵ is the base of the Naperian system of logarithms, and h and k are arbitrary constants. The equations may be verified by differentiation, and found to satisfy the differential equations (14 and 17), of which they are the complete integrals. If we know how the current or potential varies with the time at any one point of the cable, the arbitrary constants h and k can be determined, and we have the complete solution of the problem, and are able to tell the potential or current at every point of the cable at any time.

If the potential is caused to vary harmonically at any point of the cable, and at that point $e=E\sin\omega t$, the constants of the general solution may be determined. When the variation is harmonic, it will be found that the constants in the general solution, which is of the exponential form, have imaginary values. The exponential solution may then be transposed into a sine-function where the constants have real values. Instead of performing this transformation from the exponential to the sine form, which is somewhat laborious, we may immediately assume the solution to be of the sine form, or

$$e=h\epsilon^{rt+px}\sin(\beta t+\alpha x),$$

where x is the distance from the source of E.M.F., and where α, β, h, r, and p are arbitrary constants to be determined so as to satisfy the differential equation (14). We see that the constant r must be zero, for, when $x=0$, the E.M.F. at the origin is $E\sin\omega t$ by our supposition. Therefore, $h=E$, and $\beta=\omega$; and only the constants p and α remain to be determined. The E.M.F. is

$$e=E\epsilon^{px}\sin(\omega t+\alpha x). \quad . \quad . \quad . \quad . \quad (18)$$

By differentiation we obtain

$$\frac{d^2e}{dx^2}=(p^2-\alpha^2)\epsilon^{px}\sin(\omega t+\alpha x)+2p\alpha\,\epsilon^{px}\cos(\omega t+\alpha x)$$

$$CL\frac{d^2e}{dx^2}=-CL\omega^2\left[\epsilon^{px}\sin(\omega t+\alpha x)\right]$$

$$-CR\frac{de}{dt}=-CR\omega\left[\epsilon^{px}\cos(\omega t+\alpha x)\right]$$

Equating the coefficients of the sine and cosine, separately, to zero, we obtain the simultaneous equations

$$p^2-\alpha^2-CL\omega^2=0, \quad \text{and}$$
$$2p\alpha-CR\omega=0.$$

Solving these equations for p and α, we find that

$$p=\pm\sqrt{\frac{C\omega}{2}}\sqrt{(R^2+L^2\omega^2)^{\frac{1}{2}}-L\omega}, \quad . \quad (19)$$

$$\alpha=\pm\sqrt{\frac{C\omega}{2}}\sqrt{(R^2+L^2\omega^2)^{\frac{1}{2}}+L\omega}. \quad . \quad (20)$$

Substituting in (18) these values of p and α, and writing Im. for the impedance $(R^2+L^2\omega^2)^{\frac{1}{2}}$, we have as the expression for the potential at any time and at any point of the conductor a distance x from an harmonic source of E.M.F.,

$$e=E\epsilon^{\pm\left[\sqrt{\frac{C\omega}{2}}\sqrt{Im-L\omega}\right]x}$$
$$\sin\left\{\omega t\pm\left[\sqrt{\frac{C\omega}{2}}\sqrt{Im+L\omega}\right]x\right\}. \quad . \quad (21)$$

The discussion of this equation will be given after the corresponding equation for current is obtained.

To Obtain the Current.

The current may be obtained from the potential equation by means of the relation $C\frac{de}{dt}=-\frac{di}{dx}$. [See equation (7).] Differentiating (18) with respect to t, and multiplying by C, we obtain

$$C\frac{de}{dt}=CE\omega\epsilon^{px}\cos(\omega t+\alpha x)=-\frac{di}{dx}.$$

Integrating this result with respect to x, we get

$$i=\frac{-CE\omega\epsilon^{px}}{p^2+\alpha^2}\left\{p\cos(\omega t+\alpha x)+\alpha\sin(\omega t+\alpha x)\right\}.$$

* [Several of the signs in equations (8) to (18) appear to us to be wrong in the manuscript supplied by the authors from the Cornell University, Ithaca, U.S.A. As, however, the changes which we think necessary only in the end alter the sign of R in (18) the equations (19) and (20) are unaltered, and the practical conclusions which follow are correct.—Ed. *E.*]

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By a trigonometic transformation this may be written in terms of the sine only, and we finally obtain

$$i = -E\sqrt{\frac{C\omega}{I m}}\,\epsilon^{px}\sin\left\{\omega t + \alpha x + \tan^{-1}\sqrt{\frac{I m - L\omega}{I m + L\omega}}\right\} \quad (22)$$

Here p and α represent the expressions (19) and (20).

This equation gives the value of the current at any time and at any point of a conductor containing distributed capacity and self-induction when subjected to an harmonic source of E.M.F. The discussion of this equation and the potential equation will next be taken up.

In order to ascertain the physical effects of distributed self-induction and capacity in a circuit, we will first discuss the analytical results just obtained as applied to a circuit in which the self-induction is neglected; and then, after investigating the nature of the wave propagation, the wave length rate of propagation and rate of decay, we will consider circuits containing distributed capacity and self-induction, noting the changes caused by the introduction of the self-induction.

(To be continued.)

AUSTRALASIAN TELEGRAPH RATES.

A deputation representing the banking, shipping, mining, and general commercial interests connected with the trade between Great Britain and Queensland, waited on Wednesday at the offices of Messrs. Gray, Dawes, and Co., No. 13, Austinfriars, on the Hon. W. Horatio Wilson with reference to the rates at present charged for telegrams to and from Queensland. The Hon. W. Hemmant (of the firm of Messrs. Stewart and Hemmant) occupied the chair; and the following firms, companies, and gentlemen formed the deputation or expressed sympathy with its object, and desired their names placed on the attendance roll:—Aplin, Brown, and Co. (W. Villiers Brown, M.L.A.), R. L. Armour and Co. (Limited), Chas. F. Moberly Bell (*The Times*), John Bell (F. Green and Co., and Orient Steam Navigation Company), Brodziak and Rodgers, Brand, Dryborough and Burns, Henry Brandon, Bank of Queensland (Limited), Bank of Australasia (P. Selby), Brabant and Co., W. Balchin, Chas. E. Bright, C.M.G., Philip Burns and Co. (Limited) (D. Patience), John Blyth and Co., D. L. Brown and Co., R. Clayton and Co. (Reginald Clayton), Central Market Cold Air Stores (Limited) (A. Towers), De Lissa, Sons, and Co. (S. De Lissa), Dalgety and Co. (Limited), Oscar De Satgé, Captain Elmslie (Elmslie and Co.), A. Forbes and Co. (Arthur Forbes), H. S. Fitter and Sons, Finney, Isles, and Co., M. B. Foster and Sons, Gray, Dawes and Co. (E. S. Dawes), Gordon and Gotch, Robert Gray, Antony Gibbs and Sons, Sir Arthur Hodgson, K.C.M.G., Hollis, Hopkins, and Co. (Limited) (T. Hollis Hopkins), S. Hoffnung and Co., G. T. Hayzen, Jeremiah Lyon and Co., B. S. Lloyd and Co., McNeil, Duncan and Co. (Sinclair MacLeay), McLean, Bros., and Rigg (Limited) (F. Chapman), James McEwan and Co (Limited), John McDonald, Parbury, Lamb, and Co., Queensland National Bank (Limited), Queensland Smelting Company (Limited), Alfred Romilly, Charles C. Rawson, Rylands and Sons (Limited), Stewart and Hemmant (Hon. W. Hemmant), Sir Thomas Sutherland, M.P., K.C.M.G. (Peninsular and Oriental Company), C. G. Tindal (Australian Meat Company), "Ramornie," Union Mortgage and Agency Company of Australia (Limited), W. Weddel and Co. (W. Weddel), Watson, Ferguson, and Co. (James Gray), Blundell H. Weld.

The CHAIRMAN, in opening the proceedings, said: I presume you are all acquainted with the object of our meeting to-day. It is to take advantage of the presence in London of a member of the Queensland Government to urge upon him the desirability of his Government joining with the other Australian Colonies in the guarantee to the Cable Companies to protect them against loss through the reduction of the tariff. A statement has been prepared by the hon. secretary (Mr. J. Troubridge Critchell) which will show exactly what our object is, and with your permission I will read it. It is as follows: On May 1, 1891, the agreement made between the colonies of New South Wales, Victoria, South Australia, Western Australia, and Tasmania, and the Eastern Extension Telegraph Company come into force; under the guarantee of the colonies named to bear 50 per cent. of any loss which might occur for the period of one year, the loss to be apportioned on a population basis, the rates for ordinary cablegrams between Great Britain and the guaranteeing colonies were lowered to from 4s. to 4s. 8d. a word. The colonies of Queensland and New Zealand declined to join the agreement, and the rates—9s. 5d. and 10s. 4d. respectively—remained the same as before. The tentative period of one year having expired, it was found that a loss (comparing the receipts at the reduced rates with the earnings of the Australasian cable traffic at the time the agreement was made) had been incurred of £55,040. This deficiency was divided between the signing colonies and the cable companies according to the arrangement stated above. It is now proposed by New South Wales and the other guaranteeing colonies to raise the ordinary tariff to 4s. 9d. a word, which increase will, so it is calculated, reduce the loss for the next year's operations to about £17,000, and therefore the colonies may anticipate being called upon to contribute, say, £8,000 as their share. It is considered probable that a new agreement on these lines will come into force about November 1st in this year. New Zealand will be a party to the guarantee. Queensland, therefore, is now the only member of the Australasian group standing out of the guarantee. The presence in London of the Hon. W. Horatio Wilson has induced the mercantile community interested in the trade between Great Britain and Queensland to form a deputation to wait upon him and respectfully urge the desirability of his Government joining the guarantee, so that the somewhat harsh disability under which persons who have to cable to Queensland, and from Queensland to Great Britain, are now placed may be removed. When Mr. Wilson was approached and asked if he would receive such a deputation he consented, and on its being pointed out to him that it would almost be an impossibility for a representative body of City men to wait upon him at the Westminster Palace Hotel he waived the point, and agreed to meet the deputation at the offices of Messrs. Gray, Dawes, and Co., kindly granted by that firm for the purposes of the meeting. It may, perhaps, be well to point out, in the most definite terms, before stating the case, that the initiation of this movement is due to the concerted action of the firms and gentlemen whose names appear on this paper; neither the cable companies nor any other interested institutions or persons have had anything to do with the formation of the deputation, directly or indirectly. The deputation respectfully approaching the Queensland Government desires to represent the hardship borne by firms and persons in Great Britain who use the cable to the colony, of having to pay 9s. 5d. a word when the tariff to the other Australian Colonies is now but a little over 4s., and will be under the fresh agreement 4s. 9d. The deputation points out that according to estimates that have been authoritatively published the loss to the guaranteeing colonies for the ensuing year (assuming that the colonies and the cable companies renew the agreement) will be about £8,000. Were Queensland to join with the other colonies her share of the loss would be about £800, and the increase of business likely to follow would probably still further reduce this sum. Under the operations of the first tentative year Queensland's share of loss, had she been one of the guaranteeing colonies, would have been about £5,000; but now that a more reasonable tariff has been proposed, and the probable loss shown to be but this small amount (a loss which the deputation contends would be made up over and over again to the community), it appears that the financial objections to the colony's joining in the agreement practically fall to the ground. The cheapening of postal and telegraphic facilities is rightly judged to be an important part of the world's progress, especially in the case of the scattered States of the British Empire. It is within the knowledge of members of this deputation that the (comparatively) high cable tariff of Queensland has affected her commercial and mining relations with the United Kingdom prejudicially. A considerable saving would accrue to the colony were she to join the guarantee, owing to the reduction on Government messages, which are now under the ordinary 9s. 5d. a word tariff; as a member of the guaranteeing colonies she would send her Government messages for about 3s. 10d. a word. The amount so saved to the taxpayers of Queensland might possibly be a considerable proportion of the £800. This deputation, representing the landed, commercial, shipping, and mining interest concerned in Great Britain, Queensland interchange, respectfully ask the Queensland Government to consider whether they cannot recede from their present position of refusal to join the cable guarantee. As the agreement is made from year to year, Queensland would, if she were to join, only bind herself for one year, and could retire at the expiration of the term if it were considered advisable to do so. The deputation have no desire to enter upon considerations of public policy; they only wish to do what has never been done before—give expression to the views of the Anglo-Queensland commercial community as to this important matter, solely from a business standpoint. They desire to indicate their earnest hope that the Government will see their way to effect this reform in the intercommunication of the communities of Great Britain and the colony of Queensland. Mr. Oscar De Satgé, who intended to be present, has telegraphed that, owing to illness, he is unable to attend; and Mr. Bright, of Messrs. Bright Bros., has written to say that, owing to a previous engagement, he cannot be with us. I do not know that I can add anything to what has been stated. We all feel that it is somewhat of an anomaly that one colony should stand out from all the others, and I feel sure from what I see of telegraphing that the Government would not be a penny out of pocket by joining in the agreement. The saving they would effect would quite make up the share of the loss which the Queensland Government would have to bear on the population basis. We know that the finances of the colony are not quite what could be wished, and I should be extremely reluctant to urge the Government to depart from the lines of economy which we all see that they are now engaged on. This, however, is a very trifling matter, and they would make up by the saving they would effect on the Government messages the amount they would have to pay under the guarantee.

Mr. E. S. DAWES, having expressed satisfaction at seeing such an influential gathering, said: The large attendance shows how very warm an interest is being taken in cheapening the communications between Queensland and the United Kingdom. Of the value of such increased communication I am sure we must all be fully aware. Not only are we hampered in our commercial transactions by the dear tariff—for none of us care to spend 10s. 1d. a word if we can help it—but it has a tendency to put Queensland into the background, a position that I myself, having a very warm regard for the colony, very strongly resent. If the effect of this really very influential meeting should be to induce the Government to give a trial to the proposal that is now made, I am sure we shall all be very grateful.

The Hon. SECRETARY announced that Mr. Moberly Bell, of *The Times*, was unable to be present, but had forwarded a letter expressing his complete sympathy with the object of the deputation, and stating that that journal might feel compelled to discontinue giving the same prominence to Queensland politics as they gave to those of other Australian colonies unless the Queensland Government could see its way to securing the same tariff rates as prevailed from and to Victoria, New South Wales, and the rest of Australasia.

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Mr. W. VILLIERS BROWN said: I can scarcely claim to be one of the mercantile community of London; but I have a great many communications with London as a Queensland merchant, and I am quite alive to the importance of the concession we are about to ask the Queensland Government to make. It is very well known to me, and to those present, no doubt, that for a considerable time past the Queensland people have been sending their messages through the other colonies. That is not a desirable thing to encourage—in fact, it is scarcely what we should like to see. I think the amount involved is, according to the figures which have been put before us—which appear to have been very carefully prepared—so small that the Government can scarcely hesitate any longer to join in the agreement. I may, however, say that I do not know that it has been a matter of economy altogether with the Queensland Government. I have no doubt that they have had some good reasons for refraining from taking part in the agreement hitherto, but that is a matter on which we have no information, and are not likely to receive any, for although we have a member of the Government present, he would not be likely to say anything on such a subject. I think it likely, however, that those reasons may no longer exist. The main point for us is, I think, to convince Mr. Wilson of the necessity of this concession, and to get him to go heartily into the subject and make representations to his Government regarding it. From what I know of matters in Queensland I feel sure that if Mr. Wilson takes up the subject heartily and puts it before his Government our prayer will be entertained. Speaking personally, I shall be very glad on my return to Queensland if I can strengthen Mr. Wilson's hands, either as a member of the Legislature or as a Queensland merchant.

Mr. JOHN McDONALD: The memorandum which has been read to us has set the whole business before us so clearly that I cannot add anything to it which would make the matter more clear. As, however, I send a good many cablegrams to Queensland, I may say that I think it would pay those in this country who send cablegrams to Queensland to take upon themselves to provide the £800 in question—that is to say, if the Government of the colony cannot do so without spending more money than they can afford. I believe it costs the people who send telegrams from this country more than the £800. It is true that the messages are not sent direct through the cable companies; they go to Reuter s, but that Company charge an extra price for sending the messages round by Melbourne, and I feel sure that that extra sum would amount to more than £8.0. There would be a gain to the people of this country—for a saving is a gain—and they would save that extra cost if the Government of Queensland would consent to join the other colonies; but I look at it that the expansion of trade through the reduction in the cost of cable messages would be of much greater advantage to the Colony of Queensland, and that a great many times £800 would be gained by them. In contrast to the action of the Queensland Government with respect to cable messages I would point out what they did with regard to the establishment of a parcels post. Last year when Mr. Wilson visited this country a deputation waited upon him respecting this matter, and the result was that a parcels post was established. I trust, also, that on this occasion the Government will see their way to grant our wish. I may mention thet Mr. Wilson deserves all the credit, or nearly so, for initiating the parcels post and carrying it through. It had to be brought into the Lower House, but he prepared a measure and carried it through the Upper House.

The Hon. W. H. WILSON: Mr. Chairman and gentlemen, I am sure I have been very pleased indeed to receive this deputation, because the matter which has been brought under my notice is one of very great importance; and certainly, from the point of view of the deputation, and the way in which it has been placed before you, it seems to me that a very strong case indeed has been made out. I feel very great sympathy for the wishes of the deputation, and I trust that my Government—I am quite sure of it—when they consider the question, will give great weight to the views of such a large and influential deputation as that which I have had the honour to receive to-day. The question resolves itself into a different form, I think, now to what it has hitherto done. The loss that is likely to accrue is so small that it is a mere bagatelle. Under those circumstances I hope and believe that the Government will now be enabled to give it a far more favourable consideration than they could possibly do under other circumstances. I shall be pleased to communicate to my colleagues the views of the deputation, as expressed in the circular which has been read, and I will also do everything that I can to further the object of the deputation.

Mr. WEDDEL, in proposing a vote of thanks to Mr. Wilson, said: Everyone agrees that any country which is to remain in the foreground of nations must have the cheapest postage and the cheapest cable communication that is to be obtained; and any country or colony that is not in that position is bound to recede into the background. Excepting Queensland all the Australian colonies—and New Zealand now—have agreed to come into this federation; but after the strong arguments which have been put forward to-day I have very little doubt, from what Mr. Wilson has said, that he will use all his influence to prevent Queensland from being in any way put into the background. I am sure that we are also greatly indebted to Messrs. Gray, Dawes and Co. for their kindness in giving us the use of this room.

Mr. ROBERT GRAY (Queensland), in seconding the resolution, said: I quite agree with Mr. Wilson that the question which has brought us together has now assumed a different complexion from what it had when the Government of Queensland felt unable to join in the agreement. The deficit now appears as if it will be much smaller, and I trust that the Queensland Government will see their way to meeting the views of the deputation. I am sure that all present agree in thanking Mr. Dawes. That gentleman's firm is well known in Queensland as most enterprising and public spirited.

The resolution was carried unanimously, and was briefly acknowledged by the Hon. W. H. Wilson and Mr. Dawes, and the proceedings then terminated.

CORRESPONDENCE.

LEAD-COATED WIRES ON BOARD SHIP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—Mr. A. A. C. Swinton, in your issue of the 23rd ult., claims, on behalf of Messrs. Sir W. G. Armstrong and Co., the credit of having been the first to introduce lead-coated wires for electric lighting on board ship, naming the Japanese cruiser "Naniwa-Kan" as the vessel in question. According to "Brassey," the vessel was built in 1885. In 1883 I proceeded to the United States of Columbia, Central America, and fitted the electric light on board the Yarrow "stern-wheeler" "Inez Clarke," using lead-coated wires. The installation consisted of a Gülcher dynamo (driven direct by a "Hodson" rotary engine taking steam from the main boiler), 45 "glow" lamps, "B.T.K." storage batteries, and a Gülcher arc lamp. The object of the latter was to disclose "snags" when travelling at night, and thus economise time in running on the river Magdalena between Barranquilla and Honda, a distance of over 600 miles. As I pointed out in the public press on my return in 1884, the object was not accomplished, as, to observers behind the light, it was useless owing to the glare from the water. This has since been found to be the case with naval search-lights.—Yours, &c., C. E. KELWAY.

London, October 5, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—*Alteration of Time.*—The time for sending in the Burnley tenders has been altered from the 26th to the *19th October.*

——— It will be seen by our advertisement columns that the Corporation of York invite tenders for the supply of the first instalment of plant necessary for lighting certain streets, and of a supplementary tender for the supply of additions to the mains and generating plant, such as may be from time to time required to extend the lighting. Specifications and explanatory plans can be obtained from G. McGuire, Esq., town clerk, to whom tenders must be forwarded not later than November 21st.

——— The Bolton Corporation are prepared to receive tenders for a lease of their tramways in the borough of Bolton and the adjoining townships of Great Lever, Halliwell, and Heaton. Tenders to town clerk by the 10th inst.

——— The Wimborne Local Board invite tenders for lighting the public streets of the town and urban sanitary district for three years from the 21st inst. Particulars and forms of tender may be obtained from Mr. H. W. Dibben, clerk to the Board, Poole-road, to whom tenders are to be sent by the 10th inst.

TENDERS ACCEPTED.—The Asylums Committee of the London County Council have accepted the tender of Messrs. Latimer Clark, Muirhead and Co. (Limited), for the electric lighting of Claybury Asylum at £15,130, advertised in our issue for July 1st. As will be seen by the list of tenders which appeared in *The Electrician* of July 29th, this was not the lowest tender submitted.

——— Out of twenty-five tenders received for the electric lighting of the Otterbourne Waterworks, advertised in our issue of September 16th, the Southampton Corporation have accepted that of Messrs. J. G. Statter and Co., Victoria-street, S.W., the amount being £235.

BRUSH ELECTRICAL ENGINEERING COMPANY.—This Company have secured an order for the supply of additional alternating current generating plant and transformers for the Chatham and Rochester Central Station.

MESSRS. JOHNSON AND PHILLIPS.—The contract for the supply of Brockie-Pell lamps for the extension of public lighting in the St. Pancras district has been placed with Messrs. Johnson and Phillips. The district to be lighted includes the Hampstead-road, High-street, Camden Town, and other principal streets.

MESSRS. PYKE AND HARRIS.—This firm have secured the contract for the wiring and fittings of the Grafton galleries.

DIVIDEND NOTICE.—In the estate in bankruptcy of F. G. Williams, lately carrying on business as an electrical engineer, under the title of Kenyon and Co., Crown Point, Denton, near Manchester, a first dividend has been declared of 10s., payable on the 15th inst., at the office of Messrs. J. D. Taylor and Co., Halifax.

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MESSRS. J. E. H. GORDON AND CO. (LIMITED).—This firm have just issued an elaborately illustrated catalogue of the various central stations which have been erected by the Company, and of others with which Mr. J. E. H. Gordon has been associated. Illustrations are given of the original Paddington Central Station, with which old readers of *The Electrician* are familiar. This is followed by descriptions of eight other central stations, including three in Ireland (Carlow, Larne, and Bray), and one in Scotland (Coatbridge). The illustrations are clearly printed; this remark particularly applies to those of the Carlow installation, an illustration on page 29, showing the interior of a station at Milford, five miles distant from Carlow, being especially good. The frontispiece to the catalogue is a fairly good portrait of the enterprising Mr. Gordon himself. The catalogue consists in all of fifty large folio pages.

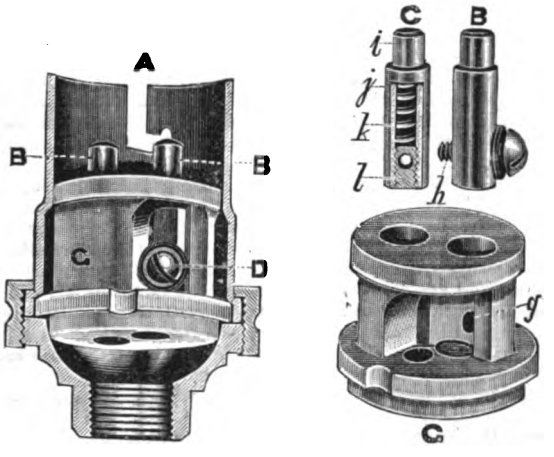
CHANGE OF PARTNERSHIP.—Messrs. Swinburne and Co. inform us that Lord Russell has ceased to be connected with them, and that Mr. Bertram R. Beale has joined the firm, which will continue to carry on the business under the same name.

REMOVAL NOTICES.—The London Battery Company (Limited) have removed from Southwark-street to Marlborough-street, Blackfriars, S.E.

——— Messrs. J. Sunderland and Co. notify removal from Raven-street to Gibbet-street, Halifax.

——— Messrs. Miller and Woods have removed from No. 34 to No. 2, Gray's Inn-road, W.C.

EVERED'S PATENT ELECTRIC LAMPHOLDER INSULATOR.—Messrs. Evered and Co. (Limited), of Drury-lane, London, W.C., and Birmingham, have recently patented an insulator for use with Edison-Swan lampholders of their make. Fig. A shows a cross-section of the holder, with the porcelain insulator in position.



B B are the terminals, D the wiring screw, and G the insulator. In the second figure C is terminal B in section, and shows the method of construction; the solid pin *i* and the nickel spring *k* are put in the socket *j*; the block *l* is then screwed in, and through this block the end of screw *h* passes into the recess shown at *g* in the insulator, thus preventing the terminal from shifting. The insulator is a solid piece of insulating material, not only between the terminals themselves, but also between each terminal and the outer brass cases, the result being that short-circuiting is impossible. By means of a ring of flexible insulating material, which is sprung over the insulator after wiring, loose strands of wire are effectually insulated from the outer case. Messrs. Evered and Co. manufacture these lampholders and insulators complete, and claim that the holders supplied by them have many advantages. They are made of extra stout metal, and are highly finished; the terminals being placed in recesses on opposite sides of the insulating bases, stray strands of flexible wire cannot even accidentally touch; the insulating base is substantially made and not easily broken; the leading-in holes are large enough to admit the insulation of the wires, thus preventing the wires touching beneath the bases; sufficient space is allowed between the base and that part of the lampholder which screws to the electric fitting: and the wires are easily connected by passing between the two washers with which each terminal screw is furnished. A vulcanized fibre collar, which does not come in contact with the current, renders a leakage to earth or a short-circuit on the case of the lampholder unlikely, but we should prefer that porcelain or other equally good insulation be used throughout. We understand, however, that these lampholders have been submitted to the surveyors of the leading insurance companies, and have met with their approval.

ATELIERS HOSTER DE SAINT NICOLAS (LIMITED).—Mr. C. J. Stewart, of 33, Carey-street, W.C., has been appointed liquidator of this Company (in liquidation).

MESSRS. WOODHOUSE AND RAWSON UNITED (LIMITED).—This firm have been placed on the Admiralty List for tenders for the construction of unarmoured wood-built boats, and the supply of engines for the same.

ELECTRO-METALLURGICAL COMPANY (LIMITED).—A meeting is called for November 5th, at 12, at Mr. J. J. B. Arter's, 26, Waterloo-street, Birmingham, to receive an account of the voluntary winding up of this Company.

REDUCTION OF CABLE RATES.—The Direct United States Cable Company (Limited) announce that on and after 1st inst. the tariff to British Columbia and North-West Territory of Canada will be reduced from 1s. 9d. to 1s. 6d. per word.

KIMBERLEY EXHIBITION.—This exhibition has been successfully opened, and the electrical installation appears to have given the greatest satisfaction to all concerned in the opening ceremony. According to the Kimberley papers to hand, the credit of the success of the installation belongs to Mr. R. O. G. Drummond, M.I.M.E.

ANOTHER EXHIBITION.—An Exhibition, to be called the Engineering Exhibition, and which is announced to include Mechanical, Electrical, Marine, and Civil Engineering, Inventions and Patent Models, is to be held at the Agricultural Hall from the 5th to the 12th November next. Mr. John Black, of Newcastle-street, London, W.C., is the secretary.

ABERDEEN.—A new hospital in connection with the Royal Infirmary was opened on Tuesday. The lighting throughout is by electricity from plans by Prof. A. Jamieson. The boilers are Babcock Wilcox, the engines have been supplied by Messrs. Marshall and Sons, and the large belts by Messrs. Tullis and Co. "Castle" dynamos are used. The installation is a very complete one, and patients will have the use of portable lamps, each bed being fitted with a reading and a portable light for examining the patients. A large number of the latest pattern E.P.S. cells are included in the installation.

BELFAST.—At the last meeting of the City Council disappointment was expressed at the absence of any report from the committee specially appointed to inquire into the details of an electric light installation for the city.

BRAY.—The Town Commissioners have decided that the arc lights shall be taken over from October 10th, without prejudice to the form or power of the lamps.

BUXTON.—At the last Local Board meeting, the proposal made by Mr. Willoughby, that the clerk should write to certain leading firms and ascertain the terms upon which they would provide plans and estimates for a considerable installation at Buxton, was agreed to, the chairman stating that before November 29th the Board should decide whether to obtain a Provisional Order or to leave the matter for private enterprise.

CAMBERWELL.—The new Camberwell public baths and washhouses have been formally opened. These baths are lighted throughout by electricity, which has cost £1,500. The installation consists of about 280 lights, the lighting of the swimming baths being effected by means of five-light electroliers suspended from the roof, and the private baths by pendants from the ceiling.

CALCUTTA.—The *Times of India* of September 3rd contains an interesting account of the lighting by electricity of the eastern half of Harrison-road, Calcutta, on the Thomson-Houston system. The installation consists of 19 1,200 c.p. arcs.

CARDIFF.—Some years ago the offices of the *Western Mail* were lighted by the electric light, but the system proved a failure and was abandoned. Last week a return was made to the electric light, of course with success.

CROYDON.—After a long discussion at the last meeting of the Croydon County Council the Corporation determined to keep the borough supply of the electric light in their own hands. The General Purposes Committee has been authorised to report upon the additional expense necessary to extend the installation for lighting the new Town Hall and Library to private consumers within the compulsory area.

DUNDALK.—At a recent meeting of the Town Commissioners a communication was read from the Board of Trade as to the renewal of the Dundalk Electric Lighting License of 1886, in which the Commissioners are recommended to amend their application so as to embrace a Provisional Order in lieu of the license, the form of which is obsolete. The suggestion did not find favour with the Commissioners.

DUNDEE.—The rules and regulations issued by the Dundee Gas Commissioners in connection with the distribution of the electric light has been issued. The price up to 20 units is to be 8s. 4d. per quarter, and 5d. is to be charged for each unit above 20. The rent for meters to be 4s. per quarter for each meter registering one unit per hour to 12s. 6d. per quarter for meters registering 15 units.

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GLASGOW.—The steam generating plant for the electric lighting of the City of Glasgow has now been delivered and erected by Messrs. Lindsay, Burnet and Co., of Govan, in the basement of the large new buildings specially erected in Waterloo-street for its reception.

HORNSEY.—At the last meeting of the Local Board a letter from the County of London Electric Lighting Company was considered, asking the Board to offer facilities for including the districts of Crouch Hill and Hornsey in the area proposed to be lighted by the Company, and asking permission for overhead wires; and also asking for a contract for lighting some of the principal thoroughfares. The Committee decided that the Local Board district covers too wide an area, only partially built over at present, for the introduction of the electric light.

LARNE.—The Town Commissioners have had under discussion the question of increasing the electric light in the town, and it has been agreed to confer with the Contractors on the subject.

LIVERPOOL.—The Liverpool Watch Committee, on Monday last, decided to recommend the City Council to adopt the principle of Electric Fire Alarms, and at the meeting of the Council on Wednesday this recommendation was adopted.

WHITEHAVEN.—A stormy meeting of the Whitehaven Trustees was held last week, at which the proposal to borrow for the purpose of an electric lighting installation came under discussion. After the expression of considerable difference of opinion amongst the members of the Board, the proposal to borrow a further £7,000, making in all £21,000, was carried by a majority of 1. It was afterwards decided to extend the installation to several districts not at present included in the scheme for lighting.

COMPANIES' MEETINGS & REPORTS.

Crompton and Company (Limited).

An extraordinary general meeting of the above Company was held yesterday (Thursday) at Mansion House Buildings, E.C., under the presidency of Mr. R. E. Crompton, for the purpose of passing the following resolution :—

"That the capital of the Company be increased to £300,000 by the issue of 22,000 additional Ordinary shares of £5 each, such shares to be numbered 8,001 to 30,000 inclusive, and to rank, as regards dividend and in all other respects, pari passu, with the already existing ordinary shares of the Company, and the Directors are hereby authorised to issue these new shares at such time and on such terms as they may think fit."

Mr. FRANCIS R. REEVES (the Secretary) read the notice calling the meeting.

The CHAIRMAN said: Gentlemen, you will have gathered from the remarks which I made at the last general meeting that our business is increasing steadily, and that fresh capital is consequently required, and you were invited to take up Preference shares at a small premium. Although the response to that invitation has not been to a sufficient extent to yield the extra capital we now require, the Directors do not care to offer the shares to the public at the price named to you shareholders, as we all of us believe that the Preference shares are worth more. After consulting with some of our most influential shareholders, some of those who are connected with the Stock Exchange advised the Board to increase the Ordinary shares, as they considered that the proportion which the Ordinary shares bear to the Preference shares in this Company is far too small. You are probably aware that Mr. Albright and myself, who were the original partners in the private firm of Crompton and Co., are still the owners of the whole of the Ordinary shares. As you know, we took the greater part of our payment in the form of Ordinary shares, carrying deferred dividend, believing it to be the best method of showing our full confidence in the future success of the undertaking, and as a guarantee that we, the vendors, would be as vitally interested in its future success as we have been in the past. Well, gentlemen, we, the ordinary shareholders, have been satisfied with our bargain, but the proposal to increase the ordinary shares certainly appeared to us at first sight to be hard on us and prejudicial to our interests, but after carefully considering the matter in all its bearings, we, who are also the largest holders of Preference shares in the Company, for which we paid cash, feel that the proposed issue of Ordinary shares will not only strengthen the position of the Debenture and Preference shareholders but will be of great advantage to us Ordinary shareholders. As I stated at the general meeting, our business has been a steadily increasing one, and there is no sign that the rate of increase will be altered in any way. During the last few months we have undertaken important contracts, and we have many others in such an advanced stage that we feel sanguine of keeping the works fully employed. Now, what are the prospects of the ordinary shareholders receiving dividends? The dividends that have been paid to us in the past are, I think, not a fair criterion of what will be paid to us in the future. It is difficult for gentlemen who are not closely acquainted with the details of such a progressive business as ours is to believe how greatly our profits in the past have been cut down by the necessity of continually spending money on new inventions, new designs and experiments necessary to enable us to keep our position as manufacturers of the highest rank; but this I can say with some confidence, that never since the very commencement of the existence of the firm of Crompton and Co. has our plant and working organisation been in as perfect a condition and so capable of carrying out our contract work economically and efficiently as at the present time. The fortunes of us managing Directors are so completely bound up with the future success of Crompton and Co. that it has been so evidently our best policy to lay down the foundations of a lasting business by extending our connections in all parts of the world, that I may say that during the last three or four years the large amount of money thus spent has been only sowing the seed for which we have yet to reap the harvest. I will read you an extract from a report of the Pretoria Lighting Company, for which we were the sole contractors. The way they speak of us, their contractors, in this report, I think is fairly representative of the way that we are generally spoken of by our customers throughout the world. After describing the works generally, they go on to say, "Your Directors think that the Company can congratulate themselves on possessing one of the most thoroughly equipped and efficient stations in existence at the present time." And further down they say, "It must be stated that the operations of the Company have been inaugurated in the most auspicious manner. It is almost without record in the electrical world that an installation of the magnitude possessed by this Company should have started and worked smoothly, successfully, and without a single hitch, as has been done in these works since the 10th of June last." From this statement and from the extracts from letters from our South Wales agent, Mr. Howell, who is now in America, it is evident to us that our inventions and the engineering skill of our staff will command a ready market in America if suitable arrangements can be entered into for carrying out work within the United States. The Directors do not entertain for one moment a proposal to invest any considerable capital in America, but it is evident that if the necessary capital can be found outside our own Company, it would be wise policy on the part of our Board to contribute some portion of the capital from the parent Company, and the profit on this capital would very materially increase our future profits. In conclusion, I have to regret the absence of Lord Emlyn, who would have taken the chair at this meeting had he been able to do so, but you are no doubt aware that he occupies the important position of Deputy-Chairman on the Great Western Railway, and he has had to attend a meeting there to-day. The Chairman concluded by moving the resolution as set out above.

Mr. J. F. ALBRIGHT said, in rising to second the resolution, he would not detain the meeting with any lengthy remarks. The Chairman had dilated upon the possible prosperity and future for the Company that might arise if work was started by the Directors themselves or on some thoroughly satisfactory basis in America; but leaving that matter out of the question, he considered that the prospects of the Company were very good, and that the expansion which had taken place in their business quite justified the Board in taking the steps which they now took in asking the shareholders to sanction the raising of additional capital. He had much pleasure in seconding the resolution before the meeting.

There being no discussion, the resolution was put to the meeting and carried unanimously.

A vote of thanks to the Chairman closed the proceedings.

The Brush Electrical Engineering Company (Limited).

The third annual general meeting of this Company was held on Friday last, the 30th ult., at the Cannon-street Hotel, under the presidency of His Grace the Duke of Marlborough.

The SECRETARY (Mr. B. Broadhurst) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, I am pleased to see that we are present in very fair numbers, so that you may hear the statements which will be made by your Directors as to the condition of the Company. It is a very good thing for a Company that its shareholders should take an interest in its affairs, and not, merely because things are prosperous, leave it entirely to the responsibilty of the Directors to appear at a general meeting and address only a few members. At the time when we met here last year I had been Chairman of this Company for only a few months, having taken up this post on the resignation of Lord Thurlow, so that this is the first complete year during which I have had the honour of occupying the chair. Therefore it devolves upon me to pay somewhat more careful attention to the condition of the Company than one would perhaps feel it one's bounden duty to do as an ordinary Director. Now, gentlemen, in drawing your attention to the leading features of our report and balance-sheet, there are a few remarks which I should like to make to you. In the first place, you will observe that your profit and loss account shows a gross profit of £55,757. 11s. 3d., and I will not go into a careful analysis of how these figures are divided, because I prefer to leave it to my co-director, Mr. J. B. Braithwaite, to give you his idea of the incidence of these figures, and how they generally affect the balance-sheet. Therefore I will confine my attention most to some general remarks with regard to these matters. In the first place, we must remember that the balance-sheet of a Company like ours requires particularly careful attention. We are essentially a trading Company—in fact, a manufacturing Company rather than a commercial undertaking. A commercial Company's business settles down to a very secure form. For instance, in the case of a bank, there must be always clients to the bank whether trade is good or bad; to a certain extent, also, the same is the case with a railway company, although, no doubt, in good times there are more passengers and

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in bad times less. This Company is a manufacturing company, and the business of such a concern depends upon the prosperity of trade and the demand for the particular article of commerce that it manufactures. That brings me to the remark that the balance sheet of a trading company requires very careful attention, and I think it should set forth very clearly, as far as the Directors feel themselves bound to do it, every detail of the Company's affairs. There was one remark made by a shareholder last year with regard to our balance-sheet which I was not exactly prepared to answer at the time, but which has remained in my mind ever since, and that was that there should be some sort of analysis of the statement which appears in the balance-sheet, of the property, patents, and goodwill—£275,321. I was asked why this item was not divided, and I confess at the moment that I was not prepared to give an answer to the question. Now, gentlemen, I have placed the matter before the other Directors, and we have discussed it at considerable length, and have come to the conclusion that in another year we will divide the item. I have no scruple myself in seeing that done because I honestly believe that it will represent good value. It divides itself essentially into two portions. It would not be right to suppose that it was all property ; it would be equally wrong to suppose that it was all patents and goodwill. There is this difference : a trading company essentially possesses goodwill, and goodwill is a legitimate and tangible asset, but it is an asset that is contingent on your existing as a company in a good condition of trade. Supposing your trade fell off—as, for instance, in the case of the silk industry of Coventry—the goodwill there would be worth nothing. Therefore, it is always wise to discriminate in any undertaking between what is property and what is goodwill. Patents are to a large extent difficult to value, and, therefore, I do not think we can discriminate between the value of patents and goodwill. But in another balance-sheet you will see a division of these two items. That brings me to a remark on the general trading of the year. Now, gentlemen, whatever may be the condition of many industries of this country—and some of them have, I think, languished a good deal, trade not having been as prosperous in many directions as we could have hoped—I think in this electrical industry there has been real steady progress. There is no doubt that to a certain extent the industry is on its trial. If there were one or two large electric financial failures connected with those large central station undertakings, I think it would create nervousness ; but on the other hand I see no necessity to have any such fear. As far as I am concerned with the large industry in the City, it affords to me complete satisfaction. I see no prospect of any disaster or difficulty occurring, and, therefore, I think I am right in saying to you that the electrical industry is on an absolutely sound commercial basis ; and as a trading Company you have very good prospects before you. The result of this year's trading has been that you are possessors of a certain abnormal profit this year, and one which cannot always be expected in every year—that is to say, a larger sum has been received on account of the City contract than under ordinary circumstances. Mr. Braithwaite will explain to you how we have dealt with that matter ; but I may briefly say that we have only taken that portion for dividend which would legitimately represent the working profits of the year. Another portion of that profit has been used for writing off certain doubtful items, and Mr. Braithwaite will explain to you how these arose, and why the Directors used those sums instead of writing them off. Another portion of the money has been put to a reserve fund, and, therefore, I say that, taking the general condition of the balance-sheet as it stands, I think it compares very favourably with that of last year. On the other hand, I am bound to point out to you that we cannot look forward to our being always in the same position, unless the trade prospers and increases. There are many competitors in this field, and there is no question about it, we cannot monopolise all the orders. In fact we are obliged, in order to be in a properous condition, to have a very large turnover in the course of a year to be able to present to you what I call a favourable balance-sheet. All these things must be remembered ; and it depends very much on the exertions of your officers and your Board whether we shall be able to keep ourselves in the van of this industry. I must say that I recognise that a great deal of work is thrown on the officers of the Company in this respect ; and in reviewing the events of the year I observe that a very large amount of labour has been bestowed by them in trying to popularise the industry among town councils and local authorities who are likely to adopt the electric light, and I hope that members of the Board will be able to assist in the same direction. In fact, the Directors of the Company must look upon themselves to a large extent as working members in a business rather than as sleeping partners. It is a business that we must have essentially pushed ; and under these circumstances, I have no hesitation in saying that I think you have a very good investment for your money, and a very good prospect for this industry. I will not go critically into the balance-sheet beyond saying a few words on certain points. The policy of the Company, as I told you last year, was to concentrate all the works at Loughborough, and we hope in the course of the year to abandon the works in Belvedere-road, and to carry everything down to Loughborough. The Directors have visited that place several times during the past twelve months, and I can speak to you, as they all can do, most favourably of the manufactory that we possess there. All the engines and dynamos made for the City of London electric lighting contract are of the most approved description, and seem to be everything that could be desired. There are several orders at present in hand, and the prospect of further ones coming in seems to be very satisfactory. You will observe that your debenture issue has been converted during the course of the year, and that you are practically borrowing now a larger sum of money for the same amount of interest. But I notice also in this balance-sheet, a thing which I am bound to call your attention to, and that is that the amount of the premium—£7,500—has been added to the property, patents, and goodwill account, and that is one of the reasons in my mind for the advisability of dividing this item, for it is well that the shareholders should understand how the amount is arrived at, and I desire to point that out to you. Now with regard to the work that has been done for the City of London Electric Lighting Company, that, I think, has met in every respect with the approval of that Company, and I think we shall have no difficulty in carrying out the contract which we have entered into. Of course you will understand that in this industry we are sometimes obliged to undertake work in which there has been no previous experience, and with regard to which we have to compete with other firms ready to give an offer on the same basis, and in such cases the result cannot always be foreseen with certainty. I am glad to say, however, that such cases are not of very frequent occurrence. We exhibited, as you see by our statement in the report, at the Crystal Palace, and the exhibition received considerable attention on the part of the public, and will have done good in bringing the position of your Company before its notice. I will now say a few words with regard to our foreign business. The Australasian trade promises, I believe, to give us a tangible profit in future years. I hope that it may progress, as there is no doubt that our colonies ought to be good customers of this Company. Regarding our Austro-Hungarian business, I may say that at Temesvar it has been acquired by the town for a fixed sum, and I think that the negotiation is practically concluded, and that we may look upon that as an asset which has been turned into money. We have in Mr. Garcke (your former managing Director) a Director who takes a great deal of trouble in the affairs of the Company, and as he was the instrument who concluded this negotiation I feel that we owe a great debt of gratitude to him. With regard to the Vienna business, I hope the day will come—and we all hope it—when we shall be able to hand it over to what I would call a native organisation, and that we shall be able to retain a sleeping interest in the same. There are so many anxieties and difficulties in carrying on an industry of this kind in a foreign country that we should all like to see our business concentrated at one spot, but we have every reason to be satisfied with the year's working. The balance sheet speaks for itself, and with regard to the item of property, patents, and goodwill, I repeat that I think that, though it has descended to us from the amalgamation, it thoroughly represents the tangible assets of the Company, and, therefore, I have every confidence in saying that you may feel satisfied with the result of the year's trading, and that the dividend which you are now to receive is one which has been honestly and fairly earned. I now beg to move the adoption of the report and accounts.

Mr. BRAITHWAITE seconded the motion, and in doing so said that as the Chairman had pointed out, in a trading company the balance-sheet might be made the means of covering up the true position of a company or of exhibiting it. In their case, the balance-sheet was one that would bear the closest investigation. In dealing with the profit and loss account first, he wished them to bear one figure in their mind, and that was that to pay 6 per cent. required £7,000 for the half-year, and to see the amount that they had written off that year, and the amount of prudence which they had exercised. The gross profit, as stated in the balance sheet, £55,757, had been arrived at after making most ample provision for anything that seemed as if it might turn out unsatisfactory in future years. They had received this year the initial payment for their large contract with the City of London Electric Lighting Company, and they had written off £4,336 as a provision against loss incurred in respect of some orders carried out in foreign countries. The financial position of some of those countries had been unsatisfactory recently, and they thought it better to write off the whole of that sum. They had also written off the entire costs in connection with the action brought against them by Messrs. King, Brown and Co. They had also made a provision of £4,000 for any possible further bad debts that might arise, although they had not any in sight. Therefore, it might be said that they had been ultra-cautious ; but it was their duty, in a Company like theirs, to be extremely cautious in their policy. Then they had written nearly £1,000 off their Provisional Order Account, and another £1,000 in connection with the opening of their show-rooms in Regent-street and the City, which might have been spread over a series of years, so that it would be seen that the gross profits brought into the balance-sheet might have been made to appear very much larger. But he thought that the shareholders would agree with the Board in placing the Company in a thoroughly sound financial position. It would be observed that their standing charges had apparently increased by nearly £5,000. That was made up of items which he would call their attention to. In the first place there was the cost of their exhibition at the Crystal Palace, which was invaluable to the Company. It had cost £2,172, and the whole of that amount had been absolutely written off this year, instead of spreading it over a series of years, which might have been done. The staff bonuses had also increased. As the shareholders were aware, the Company were working on the profit-sharing system, and although they had made but a moderate amount of progress with it what they had done was satisfactory. They had 64 of their officers and *employés* on the bonus list, and it was their expectation to make an extension of the system by which the weekly wage-earners would benefit. He believed that this was the best way of dealing with the labour question, namely, to identify the interests of the men with those of the Company by which they were employed. Although there had been an increase in the standing charges this past year, they might, if not next, at least the following year, expect to see a considerable decrease in that item. They were now erecting at Loughborough an additional factory, which would enable them to concentrate their whole works there. By the removal of the whole of their operations to one place they would effect a great reduction in the fixed charges. It was hardly likely that they would be able to move altogether before the beginning of next year, so that only a portion of the benefit would appear in the next accounts, but in the following twelve months the decrease in the standing charges would be more apparent. The Chairman had already dealt with the item of property, patents, and goodwill, as well as that of

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the redemption of debentures, £7,500, which arose in a manner which was directly beneficial to the Company. They had £75,000 Six per Cent. Mortgages of the Company which they had an option of redeeming at 105 on December 1, 1892, but to save time they had issued £125,000 Four and a-Half per Cent. Perpetual Debenture Stock, granting £110 of the new Four and a-Half per Cent. Stock for every £100 Six per Cent. Mortgage Debenture. This had effected a considerable economy in interest to the Company. The whole of those debentures had been redeemed on that basis. A large portion of the holders accepted these terms; and the balance was taken from them by a firm of brokers to complete the conversion. The result of that conversion showed the satisfactory credit in which the Company stood, and when a quotation was asked on the Stock Exchange, the price would be likely to stand at a considerable premium. The new arrangement gave them £18,500 additional capital, without costing them sixpence, which was a beneficial operation for the Company, and fully justified the action of the Directors. The next item was stock, from which they would see the thoroughly sound position they were in. The figure of stock in process of manufacture altogether amounted last year to £78,236, and this year it was £77,990, or practically the same figure. The shareholders, therefore, would see what that fact implied. It meant that they had sold the whole of their output; they had also disposed of some £4,000 or £5,000 worth of obsolete material, and that had been replaced by stock which had a ready market. The expenses of share and debenture issues, £1,743, he thought would be regarded as moderate in view of the benefits received. With regard to the Debenture Stock the amount shown in the balance-sheet as issued was only £111,347, the total authorised issue being £125,000. They would be glad to know that the balance of that stock had been issued and placed so that the whole amount now would be quoted in the market. As to the reserve account, that, as the Chairman had explained, arose out of their contract with the City of London Electric Lighting Company. In this connection they were asked to do an unusual thing. They were asked to take a contract under very stringent conditions for delivering certain machinery for producing a certain amount of electric power, and the machinery was such as had never been made before. In view of the fact that they were asked to give a binding contract, it was necessary to add a certain sum for contingencies beyond what they would have done under ordinary circumstances, to provide against the loss they might sustain by making the experiment of producing those unusually large machines He thought, therefore, it was a very wise course to adopt to carry a certain amount to a contingent fund. If all their machines turned out satisfactorily, the reserve sum of £15,000 would become an asset, available for dividend in future years; but he thought they were wise in keeping it in hand to meet any possible mishap that might occur in course of carrying out the contract. He did not know that there was any other point to which he need call attention, except to say that they proposed to reduce their property by another £3,000, and to take £800 for preliminary expenses and carry forward £753. They had eliminated every possible source of weakness in the accounts, and he thought that the dividend-paying prospects of the Company were distinctly bright. They might have paid a much larger dividend on this occasion, but he believed the shareholders would support the policy the Board had adopted. If there was any change made it would be in the direction of increasing the distribution on the ordinary shares. He had great pleasure in congratulating the shareholders in having entered at last on a career of commercial success, which so many of them had looked forward to through long years of waiting, difficulty, and cloud. He thought that they were fairly out of the wood, and on the high road to prosperity.

Mr. CHAS. R. FRY said after the clear statement given by the Chairman and Mr. Braithwaite, it must be received by the shareholders with great pleasure. The latter gentleman had referred to the question of the issue of increased capital to the amount of £11,000. Now, if they looked to the other side of the account they would see an item "by expenses of share and debenture issues, £1,743. 6s. 7d," and the information he wished to ask was this: How was it that the Company received only par value for those shares while the expense of the issue stood at such a high figure? If anybody would take the trouble to look at the official prices quoted on November 1, 1891, he would see that the shares of the Company stood at a considerable premium. He wished also to ask when the shares were issued and to whom they were allotted.

The CHAIRMAN said that so far as he knew the Directors had no interest whatever in the issue of the shares in question, nor had they taken any of them.

Mr. BRAITHWAITE explained that there were a small number of preference shares uniasued, and as the Board could at the time of the issue usefully employ a little capital in the extension of their works, he had been instructed by the Board to see whether he could not get a bid for the shares. He communicated with various dealers in the market—he was sorry Mr. Fry was not invited—to bid for them, and two or three of those dealers joined together and gave a bid for the whole lot at par. The shares were about par in November, 1891; therefore, he did not think they had done badly. They got the whole of the capital without going to the expense of circularising the shareholders and advertising so trivial an issue.

The CHAIRMAN said that there was a very great difference between buying and selling shares, and as to the services of Mr. Braithwaite as broker of the Company he (the Chairman) could say, having sat at the Board and knew it, that the Company would not have been in existence but for the efforts exerted in its behalf by that gentleman.

A SHAREHOLDER said that a circular should have been sent round to the shareholders to give them the first call on the shares. Anyone would have been pleased to take them over on the terms offered.

Mr. BRAITHWAITE was exceedingly sorry that the gentleman who had just spoken had not also been invited to take the shares up. The preference shares had never been at ¾ premium, as had been alleged.

Another SHAREHOLDER thought that there had been too much speculation in the shares of the Company.

The CHAIRMAN said he had never bought or sold a single share since he had been a member of the Board, and so far as he knew this statement applied to every other member.

Mr. BRAITHWAITE said that the 25,000 shares were offered to the shareholders, and now that the Company was on the high road to success, some of them regretted that they did not avail themselves of the offer.

Mr. FRY said they never had any chance given to them.

Several shareholders spoke in support of Mr. Braithwaite's contention.

The CHAIRMAN said that he thought they were perfectly justified in paying a dividend of 6 per cent. The position of the Company was far more satisfactory than at any previous time. He would not have been willing to see a higher distribution made, because he thought that the items referred to should be written off, not in the course of years, but in one year. He then put the motion, which was carried.

On the motion of the CHAIRMAN, seconded by Mr. BRAITHWAITE, a dividend at the rate of 6 per cent. per annum on both preference and ordinary shares was then declared.

Mr. COPLAND proposed, and a SHAREHOLDER seconded, the re-election of Messrs. E. Woods and E. Garcke to their seats at the Board.

The motion having been carried,

Mr. SMART proposed the reappointment of the auditors, Messrs. Cooper, Bros. and Co., with an increased remuneration of 100 guineas.

Mr. COPLAND seconded the motion, which was carried.

Mr. FRY proposed a hearty vote of thanks to the Chairman.

A SHAREHOLDER seconded the motion, which was cordially passed.

The CHAIRMAN having expressed his acknowledgment, the proceedings terminated.

Pretoria Lighting Company (Limited).

The following is the Directors' report for the period ended June 30th last to the shareholders of the Pretoria Lighting Company (Limited):—

Building and Machinery Contracts.—The contract for the station buildings was placed in the hands of Messrs. Murdoch and Haldane, who have executed their work to the satisfaction of the Board. Messrs. Crompton and Co. (Limited) handed over the electrical machinery and plant on June 1st last. Your Directors called in Mr. J. Hubert Davies, electrical engineer of Johannesburg, to inspect the whole of the works. Mr. Davies has sent in a preliminary report, and will send in a final one after September 1st, when the three months' trial run of the machinery by the contractors is concluded.

The shareholders will remember that Messrs. Crompton and Co. (Limited) bound themselves under a penalty clause to complete their works by March 31st last. As this was not carried out, this matter was also referred to Mr. J. H. Davies, who advised your Board that good and valid reasons had been advanced by Messrs. Crompton and Co. (Limited) for the non-fulfilment of their undertaking.

The Extension System.—On the arrival at Pretoria of Mr. J. Cushny (Messrs. Crompton and Co.'s representative) it was discovered that the original system of distributing the mains was unsatisfactory and unworkable.* A new plan was devised (involving an additional expenditure of rather less than £3,000), which your Board sanctioned, and which is now nearly completed, whereby the distribution of the electric current is made available at every house within the boundaries of the city.

The Electrical Machinery.—The plant consists of five sets of boilers, engines, and dynamos, together with 102 lamps for street lighting, with all poles, insulators, &c.; about 36 tons of copper conductors, distributed on the underground and overhead systems; and with all necessary instruments required for a central station. Your Directors think that the Company possess one of the most thoroughly-equipped and efficient stations in existence at the present time. The plant is capable of supplying current to about 6,000 8 c.p. lamps, in addition to the public lighting contract.

Supply of Current.—The Company started on June 10th last the supply of light to 48 of the public lamps, to the State printing office, and to a few private consumers. The whole of the public service could not be started simultaneously, as a certain number of the lamps are on the extension system, which will not be finished until September 1st. Up to date 72 private installations have been, or are being, connected to the Company's mains. A full statement of all installations made up to the date of the general meeting will be laid before the shareholders for inspection.

Management.—The Directors have secured the services of Mr. John Cushny, resident engineer, the appointment to date from Sept. 1st next, and have appointed Mr. Hirschel Cohen to the dual position of manager and secretary.

Messrs. C. Hanau and J. B. Taylor retire in order of rotation, but are eligible and offer themselves for re-election as directors. A new auditor (or auditors) in the place of Messrs. Cowen and Wilkinson, who have left the State, and the confirmation of the appointment of Mr. A. Scott Rankin as auditor of the present accounts (and as to his remuneration), will form a portion of the business at the forthcoming meeting of the shareholders.

The report concludes with the announcement that the Directors have decided that the amount of £4,543. 5s. 8d. expended during the past three years on the various items effecting the formation of the Company, and

* With reference to the above report (under the heading "The Extension System") it should be stated that the necessity for re-arranging the original system of distributing mains was owing to no fault of Messrs. Crompton and Co., who worked to the designs of the original engineer to the Pretoria Company, whose position is now occupied by Mr. Cushny, as stated above. Messrs. Crompton and Co. are certainly to be congratulated upon the success of the Pretoria installation.

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other amounts not directly chargeable to the construction account, shall be written off over a course of seven years, and the amount that will consequently be charged annually to profit and loss account will be £649. 0s. 10d.

NEW COMPANIES, STATUTORY RETURNS, &c.

CARBON BATTERY COMPANY (LIMITED).—This Company was registered on September 28th, with a capital of £10,000, in £1 shares. The objects are to manufacture, sell, and deal in electricity, and the bye products arising from the manufacture thereof, to manufacture, sell, and deal in aluminium, and metals alloyed with aluminium, magnesium, and other metals, and in chemicals and other substances arising out of the manufacture or otherwise; to purchase or otherwise acquire letters patent for the following and other inventions:—"An improved process for the manufacture of electricity direct from carbon; the recovery and purification of the bye products arising therefrom, and apparatus therefor," and to develop, turn to account, exploit, grant licences in respect of, and manufacture in accordance with, the said and other inventions. The subscribers are:—S. Willington, 28A, Basinghall-street, E.C.; F. A. Freeland, 11, Richmond-road, Barnsbury, N.; Charles E. Jolly, 29, St. George's-road, N.W.; Henry Russell, 74, Chancery-lane, W.C.; Leopold Herz, 49, Grosvenor-road, Highbury New Park; Charles H. Russell, 34, Chapter-road, N.W.; John T. Shrives, 337, High Holborn.

NEW ELECTRO-METALLURGICAL SYNDICATE (LIMITED).—This Syndicate was registered on September 28th with a capital of £10,000, in £1 shares. The objects are to acquire, develop, turn to account, grant licences in respect of, and manufacture in accordance with, an invention for "an improved process for the production of metals by electrolysis and the recovery and purification of the bye products arising therefrom and apparatus therefor."

Similar in capital, shares, and signatories to the above Company there have also been registered the **New Glass Syndicate (Limited)** which proposes to exploit, develop, and turn to account certain inventions relating to the manufacture of glass; and the **New Sulphur Recovery Syndicate (Limited)** which will deal with the manufacture of sulphur and the utilisation of its bye products.

MISCELLANEOUS.—BUTE DOCK FOUNDRY (LIMITED), iron and brass founders, mechanical and electrical engineers, steel converters, &c.; capital, £10,000, in £5 shares.——UNITY ELECTRO-PLATING COMPANY (LIMITED), electro-platers, silversmiths, and jewellers, carried on by J. B. Finnemore at 125, Great Charles-street, Birmingham; capital, £5,000, in £5 shares.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The first annual return of the above-named Company, made up to September 15th, was filed on the 27th. Out of a nominal capital of £800,000, divided into 40,000 ordinary and 40,000 preference shares of £10 each, 39,006 ordinary shares have been taken up, and the full amounts called, resulting in the payment of £38,998, and leaving £62 in arrears.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The annual return of this Company, made up to June 24th, was filed on September 29th. The nominal capital is £307,545, divided into 75,000 £6 per Cent. Preference Shares of £1 each, 224,850 ordinary shares of 14s. each, and 75,150 ordinary shares of £1 each. £7,637 preference and 224,850 ordinary shares have been taken up, the full amount called, and all calls (£185,032) paid.

D. HULETT AND CO. (LIMITED).—The annual return of this Company, made up to September 12th, was filed on the 16th, The Company was registered on July 30, 1889, with a capital of £35,000, divided into 6,900 ordinary and 100 founders' shares of £5 each. At the time of making up, 5,900 ordinary and the founders' shares had been taken up, of which 4,000 ordinary and the founders' shares had been issued as fully paid. Upon the remaining 1,900 ordinary shares the full amounts had been called, and all calls (£9,500) paid.

HALIFAX MUTUAL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, made up to August 20th, was filed August 29th. The Company was registered on March 27, 1889, with a capital of £20,000, in £5 shares. At the time of making up 1,226 shares had been taken up, of which 105 had been issued as fully paid. Upon the remaining 1,121 shares, £3. 10s. per share had been called, resulting in the payment of £3,926 (which includes a sum of £2. 10s. paid on five forfeited shares).

HEAD, WRIGHTSON AND CO. (LIMITED).—The second annual return of this Company, made up to July 2nd, was filed August 23rd. The Company was registered on June 21, 1890, with a capital of £210,000, in £5 shares. At the time of making up, all the shares had been taken up, the full amounts called and all calls paid. Share warrants to the total amount of £24,270 (4,854 shares) are outstanding, and share warrants to the total amount of £730 (10 warrants of 10 shares each, 2 of 20 shares each and 1 of 1 share) have been surrendered since last summary.

KEIGHLEY ELECTRICAL ENGINEERING COMPANY (LIMITED).—The statutory return of this Company, made up to May 6th, was filed on August 2nd. Out of a nominal capital of £10,000, in £1 shares, 2,408 shares have been taken, of which 2,400 have been issued as fully paid. Upon the remaining eight shares the full amounts have been called, and all calls paid. By an agreement dated July 19, 1892 (filed August 15, 1892), between Henry Boardman, Ira Ickringill, and Charles J. Garnett, and the Company, the Company allotted to each of the vendors 300 fully-paid shares in consideration for certain patents and patent rights, particulars of which are not given.

LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE (LIMITED).—The annual return of this Company, made up to August 3rd, was filed on August 5th. The Company was registered on March 18, 1889, with a capital of £40,000, in £100 shares, which has since been increased to £100,000 by the creation of 6,000 shares, of £10 each, and the 400 shares, of £100 each, have been subdivided into 4,000 shares, of £10 each. At the time of making up 4,716 shares were taken up, of which 1,330 had been issued as fully paid. On 2,660 shares the full amounts had been called; on 397, £2. 10s. per share called; and on 329 shares £5 per share had been called, resulting in the payment of £29,237. 10s.

MADRAS ELECTRIC TRAMWAYS COMPANY (LIMITED).—The statutory return of this Company, made up to July 28, 1892, was filed on August 9, 1892. The nominal capital is £100,000, divided into 100,000 shares of £1 or Rs.15 each. 14,000 £1 shares have been taken up, 5s. per share called, and all calls (£3,600) paid; 6,273 shares of Rs.15 each have been taken up, Rs.4 called on each, and up to the time of the last advice from India, August 8, 1892, Rs.12,546 had been paid, leaving a similar sum in arrears.

MIDLAND ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, made up to September 14th, was filed on the 23rd. The Company was registered on December 12, 1681, with a capital of £50,000, in £10 shares; and at the time of making up 3,139 shares had been taken up, of which 3,132 had been issued as fully paid. The full amounts have been called and paid on the remaining seven shares.

NEW CADOGAN AND BELGRAVE ELECTRIC SUPPLY COMPANY (LIMITED).—At Extraordinary General Meetings of the above-named Company, held at the offices, 91, Manor-street, Chelsea, S.W., on June 20 and July 6, 1892, the following special resolutions were duly passed and confirmed:—(1) "That the name of the Company be changed to 'The St. Luke's Chelsea Electric Lighting Company (Limited)'"; and (2) "That the capital of the Company be increased to £30,000 by the creation of 2,900 new shares of £10 each." The official notices of such increase were filed on July 14, 1892, the permission of the Board of Trade for the said change of name granted on July 20, 1892, and the certificate issued July 22, 1892. The Company was registered on June 30, 1890, to carry on the business of the Cadogan Electric Light Company (Limited). The last return (filed January 7, 1892) showed that only seven shares had been taken up and no calls made.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The accounts of this Company, subject to audit, show a profit sufficient to enable the Directors to recommend a final dividend of 3s. per share, making, with previous distributions, a total dividend of 6 per cent. for the year ended June 30th last, and also the payment of a bonus of 1s. per share, both free of income-tax, which together will amount to £26,000, leaving a balance of £43,073. 8s. 5d., of which amount £40,000 has been placed to the reserve fund, increasing that fund to £579,714. 6s. 1d., and £3,073. 8s. 5d. is carried forward. For the purpose of paying the above dividend and bonus on the 20th inst. the register of transfers will be closed from the 10th to the 19th inst., both days inclusive.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—Letters of allotment and regret in respect of the recent issue of £200,000 Six per Cent Cumulative Preference Shares were posted yesterday.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 2nd were £786, as against £748 for the corresponding period of last year, being an increase of £38. The total receipts for half-year amount to £10,757, against £9,874 in the corresponding period of 1891, being an increase of £883.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts for the month of September were £3,100, as compared with £3,055 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the month of September were £2,011, against £2,004 for the corresponding period last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of September amounted to £55,710, and to £56,589 in the corresponding period of 1891, a decrease of £879.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of September amounted to £42,585, and to £40,585 in the corresponding period of last year, an increase of £1,999.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—Sir Daniel Cooper, Bart., has been appointed Vice-Chairman of this Corporation, vice Mr. J. S. Balfour, M.P., resigned.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for September amounted to £24,000; and from January 1st to September 30th to £199,600. In the corresponding months of 1891 and 1890 the amounts were £213,400 and £206,800 respectively.

SOUTH AMERICAN TELEGRAPH COMPANY (LIMITED).—This Company announce the opening of a new submarine route between Europe and South America by the Company's cables from Senegal to Pernambuco, in connection with the Spanish National and Eastern Companies' systems between London and Cadiz. The Company has opened receiving offices for messages at 106, Cannon-street, and 27, Royal Exchange. Telegrams can also be handed in at the offices of the Eastern and Direct Spanish Telegraph Companies. Messages for this Company's lines are to be directed "via Teneriffe."

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REUTER'S TELEGRAM COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend at the rate of 5 per cent. per annum, free of income tax, for the half-year ending June 30th last, payable on the 12th instant.

SUBMARINE CABLES TRUST.—Notice is given in our advertisement columns that on and after the 15th inst. the sum of £1. 10s. on account of the coupon due October 15th next will be paid by Messrs.-Glyn, Mills, and Co., at 67, Lombard-street, between 10 a.m. and 2 p.m. The coupons should be left with the bankers for examination four clear days before payment.

TELEPHONE COMPANY OF AUSTRIA (LIMITED).—The Directors of this Company have declared the usual half-yearly dividend of 6 per cent. on the preference shares, payable forthwith.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the fortnight ended Sept. 30, 1892, were £2,470, compared with £1,602 for 1891, showing an increase of £868.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Sept. 30, 1892, were £3,613.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. Sept. 28.	Price Wednesday, Oct. 5.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 5. Highest.	Lowest
			TELEGRAPHS.			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	48 49	49 50	5 6 0	Jan , Apr., July, Oct.	49½	..
£2,876,140	Stock	25/0	Do. Preferred	89 90	90 91	6 0 11	,, ,,	91	90
£2,876,140	Stock	5/0	Do. Deferred	9½ 10½	10 10½	..	,, ,,	10 7/16	9⅞
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11 11½	11 11½	6 1 9	Mar., June, Oct., Dec.	11⅝	11
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	155 165	168 173	4 0 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 19 2	February and August	12	..
6,000	10	10%	Do. Preference 10%	17 18	17½ 18½	5 8 1	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (£4 paid) xd	3¼ 3⅜	3¼ 3⅜	4 16 9	April and October.	..	..
6,000	5	10%	Do. Preference 10% xd	9 10	9 10	5 0 0	,, ,,	..	..
60,710	20	3/6	Direct United States	11⅝ 11⅞	11⅜ 12	5 16 8	Jan., Apr., July, Oct.	11 1/16	11⅜
400,000	10	5/6	Eastern	14⅜ 15⅛	14⅜ 15⅛	4 6 8	,, ,,	15 1/16	14 13/16
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16	15⅛ 16	3 15 0	,, ,,	16	15⅝
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111 114	111 114	3 10 2	May and November	113	..
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15 1/16 15⅜	15½ 15⅝	4 10 4	Jan., Apr., July, Oct.	15½	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	109 112	109 112	3 11 5	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	,, ,,	10 1/16	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103 106	103 106	3 15 6	February & August	..	..
180,227	10	3/9	Globe Telegraph and Trust	10½ 10⅝	10½ 10⅝	4 12 4	Jan., Apr., July, Oct.	10 7/16	10½
180,042	10	6%	Do. 6 per Cent. Preference	15⅜ 15⅝	15⅜ 15⅝	3 16 10	,, ,,	15 5/16	15⅜
150,000	10	5/0	Great Northern	18½ 19	18¾ 19	4 9 6	Jan., April, and July	18 1/16	18 1/16
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	42 44	42 44	5 13 8	May and November	43½	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 103	5 11 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October...	..	..
3,381	£100 Cert.	£1⅞	Submarine Cables Trust 6%	116 121	116 121	4 19 2	,, ,,	118½	..
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	102	101½
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	3⅜	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	103 107	7 9 7	June and December	105	1 4½
88,321	10	6d.	West India and Panama	1 1½	1 1½	..	,, ,,	1 1/16	1½
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 9¾	9¼ 9¾	6 3 1	May and November	9⅜	9 1/16
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	,, ,,	..	..
64,242	15	6/0	Western and Brazilian	8⅜ 9½	8½ 9	6 13 4	,, ,,	9½	8⅜
33,129	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 6⅝	6 6½	5 15 3	,, ,,	6⅝	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2½ 3	2½ 3	..	,, ,,	2⅝	2½
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	,, ,,	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123 128	123 128	5 9 5	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	97 102	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
224,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	5/16 7/16	5/16 7/16	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅜ 4⅝	6 3 1	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½ 14½	13½ 14½	4 4 3	,, ,,	14½	14 1/16
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13¼ 13¾	13¼ 13¾	4 7 3	,, ,,	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	111 113	111 113	3 19 8	January and July ..	112½	111¾
48,000	£10	..	New Telephone, Limited (£2 paid)	1 1½	1 1½	..	..	1 1/16	..
58,000	5	1/0	United River Plate	1 2	1¾ 2¼	..	January and July .	2 1/16	2
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	—	—	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	—	City of London Electric Lighting (fully paid)	10½ 11	10 10½	..	—	10⅝	10½
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	..	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	2⅛ 3⅛	.. ..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5 5½	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 5⅝	.. ..	5 4 4	January and July ..	..	..
90,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16	3 7/16 3 9/16	3 15 9	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	4 6 9	March	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	—	—	—
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7	6½ 7	..	..	6 13/16	..
£50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4 4½	4½ 5½	—	—	..	..
18,680	£5	2/6	St. James' and Pall Mall	7¾ 8¼	7¾ 8¼	—	—	..	..
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	—	—	8¼	8⅛
42,853	5	3%	Westminster Electric Supply (fully paid)	6 6½	6 6½	2 6 2	—	—	—
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/9	Brush Electrical Engineering	2⅞ 3⅛	2⅞ 3⅛	..	..	3⅛	3
69,996	2	6%	Do. 6 per Cent. Preference	2 2½	2⅛ 2⅜	5 1 1	..	2½	2
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5¾	5½ 5¾	6 1 9	January and July ..	5⅞	..
12,139	5	17%	Edison and Swan United	.. ..	— —	..	—	—	—
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	2⅞ 3⅛	.. ..	..	..	..	..
45,000	10	12/0	Electric Construction	4¼ 4⅜	3¾ 4	..	—	4⅜	3 13/16
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜ 2⅝	2¼ 2⅜	—	—	2¼	2 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha & c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22⅝	21⅞
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/9 4/3	3/9 4/3	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3½ 4	3½ 4	9 12 6	May and November	3⅞	..
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	44 46	5 4 4	March and July.....	45½	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July .	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£3. 15s. paid)	½ ¾	.. ..	..	—	—	—
—	£5	8%	Do. Preference (fully paid)	2½ 3	.. ..	..	—	—	—
			RAILWAYS AND TRAMWAYS.						
50,000	£10	½%	City and South London Railway	2½ 3½	2½ 3½	1 8 6	—	3	..

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THE ELECTRICIAN:

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NOTES.

In the course of the discussion on a National Physical Laboratory at the last meeting of the British Association, Lord Kelvin said, "If any private individual will come forward with £500,000 to endow the nation with a physical laboratory, certainly the gratitude of the world will be accorded him. But if it is of national importance, is it dignified that we should wait for a millionaire to do it? It is a very poor argument to use to the Government: 'If you wait long enough there may be a chance of some millionaire in this country or in America doing it for us.'" With true scientific disinterestedness he appeared to suggest that whether such an establishment be founded in this country or elsewhere would be of small moment, so long as the cause of science was advanced. But the arguments for Government endowment were not, as a whole, remarkable for their cogency, and consisted chiefly in pointing to Germany and asking why England should not do likewise.

There are, we think, weighty reasons for preferring that a National Physical Laboratory should be independent of Government patronage and control, quite apart from any socialistic or individualistic principles. Although the building and equipment of the Imperial Institute is an extraordinary example of what can be done by public subscription prompted, only indirectly, by utilitarian considerations, it would be extremely difficult to rouse a £500,000 enthusiasm for five-figure physical determinations. In common with Prof. Fitzgerald we have recently called attention to the economy of utilising, if possible, one or several of the existing establishments as a nucleus for such a laboratory, and the munificent donation of £20,000 by Mr. Thomas Hodgkins, of Setanket, to the Royal Institution, to be applied in the promotion of scientific research, seems to point out the direction in which we can best give scope to our English instinct for infusing new life into old institutions.

The Royal Institution has always been connected with pure research, and supported as it is largely by the intelligent public, who can claim little connection with science other than forming attentive audiences at lectures and discourses, its services to science and especially to physical science can never be gainsaid. To the names of Young, Davy, Faraday and Tyndall may be added Rayleigh and Dewar. The important researches upon the liquefaction of oxygen, and the still more important investigations which have been commenced, with the assistance of the powerful refrigerating apparatus thus afforded, are the outcome of the presentation of considerable sums by individual subscribers. The efficient application of such a sum of money as that which Mr. Hodgkins has given is rendered much more likely when it is received by an institution in full working order, and with all the prestige of an historic past, than when a large part of it has to be spent in bricks and mortar and in starting a brand new organisation. The energy of the money thus spent becomes latent. We do not hesitate to use the term energy, for by it we mean the power of doing work; and not only is it latent, but in suffering a change of state, the money goes out of the world of science into the building trade. We hope that the efficiency of conversion of this £20,000 into scientific research will encourage other benefactors to turn some of their balances into kinetic cash, and thus bring the establishment of the much-needed national physical laboratory within measurable degree of realisation.

We publish this week a communication from Mr. Walter Judd, the Eastern Extension Telegraph Company's Manager in China, on the subject of Submarine Cable Relays, which will be read with interest. The modesty which characterises the confession of these comparative failures is not less noteworthy than the perseverance and ingenuity displayed in the experiments described. We have only one fault to find with descriptions of this kind, namely, that they do not come to hand more often. Fruition, it is true, is the great object of all experiments; but very much may be learnt from essays in the direction of success, though they fall short of it; and we fancy that the problem of cable relays, like many other difficult tasks, would be sooner solved, if experimenters would let the rest of the world know what they have been trying, and what has been the cause of their lack of success.

We note that the Town Council of Wigan, which, by-the-bye, owns the Gas Works, has received less than ten favourable replies to a recently-issued circular with regard to the adoption of the electric light. We do not know how the Wigan circular was worded, but if it was anything like as pressing an invitation to take the electric current as is usual where a municipality owns the Gas Works, the meagre response probably did not surprise the authorities concerned. We remember a similar circular which opened somewhat as follows:

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"Assuming that electricity will cost you x times the price of gas, are you prepared to take a supply in the event of the Gas Committee laying down an electric lighting plant?" The correct answer to this equation is, of course, negative.

THE printing of mathematical symbols, to which Mr. MITCHELL refers in our Correspondence columns this week, is a matter of considerable importance, both to writers and to readers, as well as to those who are responsible for bringing these two sections of the community into communication. A matter quite as serious as the ease of setting the type is the legibility of the author's writing. Some authors write their indices or exponents well above the line, but too often they "cock them up," to use the printer's expression, almost imperceptibly. Anything that will help to make the author's intention (we will not say his meaning) clear would be welcome. Prof. S. P. THOMPSON has made a suggestion which has one excellent feature, namely, that the expression runs on in a single line. The trouble of setting the symbols $\frac{dy}{dx}$ is so much greater than setting dy/dx, that the line containing the former counts as six lines to the compositor. This is explained by the fact that spaces must be specially cut to fill up the "whites" between the lines, and these "whites" are moreover very unsightly. While Prof. S. P. THOMPSON's notation $A\,exp[-ax]$ avoids this difficulty, Mr. MITCHELL's arrangement does not do so. It will be observed that the "leading" of his letter is irregular. "Leads" have to be specially cut to fit the bit of "rule" above or below the line, and this line, therefore, counts as two. The / , called the solidus or shilling mark, is to be found in all complete founts of type, but the \ would have to be specially cast for those writers who employ them, unless one of the compositor's ingenious makeshifts could be used. We must confess that Prof. S. P. THOMPSON's proposed notation is not altogether satisfactory, for the "cocking up" of the index conveys at a glance the suggestion of being *raised* to the power far more clearly than the letters *exp*. The solidus should be used when a fraction occurs in the course of running text, but when mathematical work is "displayed" or set out, there is not much advantage in its use. The solidus cannot be used where there is more than one term in the numerator or denominator. The expression, for example, $\frac{I\,m - L\,\omega}{I\,m + L\,\omega}$ cannot properly be written $I\,m - L\,\omega/I\,m + L\,\omega$. With regard to the disappearance of the ϵ to which our correspondent alludes, we can only say that Prof. S. P. THOMPSON's letter to *Nature* was faithfully reproduced in our Notes last week. Finally, owing to the increase in technical literature and the consequent use of mathematical symbols, the question of cost should by no means be lost sight of. If some simple method of expression could be devised it would have an appreciable effect upon the cost of scientific books.

ALTHOUGH there seems to be no end to the variety of lampholders, cut-outs, and switches that are now on the market, ingenuity seems to be spent upon innumerable modifications of a few types of fittings rather than upon real novelties. That several devices which we could name are rarely, if ever, to be found in such catalogues as the elaborate one which Messrs. VERITY AND SONS have just issued, may, of course, be accounted for by the fact that there is little or no demand for them. On the other hand, the demand for regulating sockets, by which the light of a glow lamp can be reduced either by a resistance or by a choking coil, has been met by the frank admission that such a contrivance effects practically no saving of current, and they are, therefore, rarely seen.

WALL-PLUGS and sockets are becoming common now that they are combined with switches, but it would often be convenient to be able to attach a portable or a temporary lamp to a fixed lampholder. For this purpose a plug of the B.C., E.S. or other type, to fit the lampholder in place of a lamp would be very useful. Such a plug, if well-designed, might be used for ordinary wall sockets, the sockets being arranged like lampholders, but perhaps with more substantial contacts and bayonets. Cauteries, laryngoscopes, &c., might be thus attached by medical men who need not carry cumbersome batteries into electrically-lighted houses. Two- and three-light "bodies" or "balls for clusters" are often used and are specially wired, but it would sometimes be convenient to attach such a fitting to a lampholder for festive occasions, and a plug to fit in place of a lamp would enable this to be done with ease, providing always that the fuses were suitable for protecting the permanent wiring.

Electric Light Legislation.—An Electric Lighting Bill has just been brought forward in the Victorian Parliament.

Personal.—Mr. Denny Lane, Secretary of the Cork Gas Consumers' Company, has been appointed a magistrate for the City of Cork.

Cavendish Laboratory.—Mr. W. C. D. Whetham, B.A., Fellow of Trinity College, has been appointed Assistant Demonstrator of Physics in the Cavendish Laboratory.

Military Projectors.—A powerful projector has been mounted at Fort d'Embourg, Liège, to light up the valleys dominated by the fort and also the outworks of the neighbouring forts.

Islington Vestry.—A motion which was brought before this vestry at its last meeting to postpone further proceedings in connection with obtaining an electric lighting Provisional Order was defeated by 39 to 15 votes.

Paris.—Only 20,000 houses out of a total of 85,000 use gas in Paris, their consumption for 1891 being about 10 million thousand cubic feet. The number of 8-c.p. glow lamps connected to supply companies' mains is about 175,000.

The Leeds Electric Tramway.—At the last meeting of the Leeds Town Council the agreement with Mr. Graff-Baker for the working of the electric tramway to Roundhay Park, which expired yesterday, was extended for a period of 12 months.

Electric Travelling Cranes.—The Gas Committee of the Manchester Corporation have decided to erect an electric travelling crane for unloading the coal barges and distributing the coal at their electric lighting station. The contract has been given to Messrs. Mather and Platt.

Transformer Efficiencies.—In a recent number of the *Elektrotechnische Zeitschrift* appeared some *calculations* by C. L. Imhoff relative to the comparative efficiency of "core" and "shell" transformers, by which is meant transformers with the windings outside and inside the iron respectively. According to these calculations, the "shell" type is the better of the two.

Wolverhampton.—At the last meeting of the Town Council the recommendation of the Streets and Lighting Committee

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that a plot of land in Commercial-road should be bought from the late Mr. Walford's trustees at a cost of £1,900 was agreed to.

L'Association Française pour l'Avancement des Sciences.—The twenty-first meeting of this association was held this year at Pau from September 15th to September 21st. Prof. Crova read a Paper on "Photometry," a new accumulator of M. Edouard Peyrusson was described, and Dr. Gautier read two Electro-Medical Papers.

The Telegraph in Mexico.—Since April last the Federal Telegraph system has gained 1,500 kilometres of new lines, the aggregate length of its lines being now 35,500 kilometres. Material is already on hand for the construction of new and important lines. Work on these lines will be undertaken as soon as the rainy season is over.

Royal Institution.—The treasurer of the Royal Institution has received from Mr. Thomas Hodgkins, of Setanket, Long Island, New York. the munificent donation of £20,000 to the funds of the institution, to be applied in the promotion of scientific research. Mr. Hodgkins recently presented £40,000 to the Smithsonian Institute at Washington.

Railway Lighting.—It is stated that owing to the success of the introduction of electric lamps for the use of passengers on the District Railway, an additional order has been decided upon, and also that it is the intention of the Midland and several other of the railway companies running out of London to follow the example of the District Company.

St. Pancras.—At the St. Pancras Vestry meeting on Wednesday last, it was explained by Mr. A. Sweet, Chairman of the Electricity Committee, that no rate would be required to be levied in respect of electric lighting purposes. Applications for the electric current were received from residents on the west side of Gorden-square, and it was decided to lay down a main for the purpose.

Electrical Connection of Lightships with the Shore.—Mr. Allen Stoneham, formerly Registrar-General of Shipping and Seamen, and lately an Assistant-Secretary to the Board of Trade, has accepted the appointment of Chairman of the Committee on Lightships, and their construction, &c. Part of the reference to the Committee is the practicability of establishing electric communication between lightships and the shore.

Research Scholarship.—Her Majesty's Commissioners for the Exhibition of 1851 have placed at the disposal of the Council of University College, London, the nomination to a scholarship of £150 for the year 1893. The scholarship is intended "to enable students who have passed through a college curriculum to continue the prosecution of science with the view of aiding in its advance or in its application to the industries of the country."

Wigan.—A question was asked at the last meeting of the Town Council as to the intentions of the Gas Committee with regard to the electric light. In reply, the Chairman said that only eight or nine people had replied in the affirmative to the Council's circular. This being so, the Committee did not think they were justified in spending £30,000 or £40,000 on the matter; nor would such a state of affairs justify any private venture in that direction.

Rangoon.—The *Indian Engineer* reports that a letter has been received from the Edison-Swan Company by the Municipality of Rangoon, offering to light Rangoon with electricity for the same cost as oil. The same number of electric lamps as there are now oil lamps would be supplied, but giving three times the light. A concession for fifty years is asked for. The Company guarantees 5 per cent. of the net profits to the Municipality.

Maidstone.—At the last meeting of the Local Board the subject of electric lighting was discussed at great length. In the end the recommendations of the Electric Lighting Committee were passed in an amended form, and the plans were ordered to be approved of by the Board before being carried out. Mr. W. C. Hawtayne was directed to prepare the plans, and to act as resident engineer for twelve months after the completion of the electric light works.

Cork.—At a recent meeting of the Committee of the Corporation having charge of the question of the introduction of electric lighting, it was decided to recommend the Council to refuse consent to the application of the Cork Gas Consumers' Company for an Electric Lighting Provisional Order. The Committee also recommended that in the event of the Gas Company applying for such powers, the Corporation should take the matter into their own hands and obtain the necessary powers.

Statistics on the Use of Steam Engines for Electric Installations in Prussia.—The total number of steam engines employed in generating electricity in Prussia has increased during the last two years by 28·2 per cent. and their output by 39·6 per cent. At the beginning of 1891 the number of engines so employed was 1·59 per cent. of the total number in Prussia, and their capacity 2·68 per cent. of the total. At the beginning of the following year these numbers had been increased to 1·94 per cent. and 3·5 per cent. respectively.

Lightning.—During a severe thunderstorm which broke over Bristol on Friday afternoon last the flagstaff on Brandon Hill was struck by lightning. The pole, which was about 50ft. high, was surmounted by a vane. The discharge struck the vane, and followed the course of the rope used to hoist the flag, which was twisted round the pole, until it reached the oak supports—a large splinter of which, weighing nearly 56lbs., it drove a distance of more than 20 yards—the discharge charred the remainder of the support, and eventually reached the ground.

Derry.—On Tuesday evening last the Londonderry Corporation unanimously adopted a resolution deciding to light the entire city by arc lamps, at a cost not exceeding £12,500. The Chairman of the Lighting Committee said the system would be similar to that adopted in Dublin, except that each street would be lighted from two distinct circuits, so that the failure of the light was practically impossible. The Gas Company charged the Corporation £2,000 yearly for the present lamps, and this sum would not only pay the interest on the loan, but provide for a sinking fund and leave £200 yearly profit.

Electric Traction in Tasmania.—An electric tramway, on the overhead trolley system, is being erected at Hobart (Tasmania) by Messrs. Siemens Brothers and Co. The line, a single track one, about 8½ miles long, is on the 3½ft. gauge. The trolley wire is carried on insulators, suspended from wires stretched across the track from tubular iron poles, which also carry the feeder wires. The cars are intended to carry 48 passengers (24 inside and 24 outside), and each one is driven by two 18 H.P. motors. Three 150 H.P. Willans-Siemens sets are provided at the generating station. The voltage employed is 500.

An Electric Water Cart.—An original method of watering the streets of Albany, N.Y., is illustrated in a recent issue of the *Electrical World*. A huge iron tank filled with water, made in the form of a street car, in order that its appearance may be more ornamental, and that it may be less likely to frighten horses, is used. A water pipe connected to the front end of the car extends out over the street and scatters the water over a large area. The pipe has a swinging joint, so that it can be turned back parallel to the car. As the car can carry a large quantity of water, and move at a comparatively high speed, it should prove useful.

Terrestrial Magnetism.—M. Moureaux, of the Parc Saint-Maur Observatory, has completed for this year his observations in connection with the construction of a magnetic chart of France. During the Spring and Summer months M. Moureaux has taken observations in the central departments, Savoy, the Vosges, and the Jura. Up to date determinations of the declination, inclination, and total intensity have been made at 459 places in France in the same manner, with the same instruments and by the same observer. Except along the coast line, all France north of the 45th parallel has now been magnetically mapped out.

Forthcoming Books.—In addition to the works mentioned in our issue of September 23rd, the following are announced as in preparation:—"Domestic Electric Lighting, treated from the

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Consumer's Standpoint," by E. C. de Segundo (H. Alabaster, Gatehouse, and Co.); "The Year Book of Science," edited by Prof. Bonney (Cassell and Co., Limited); "The Students' Chemistry," by R. L. Taylor (Sampson Low and Co., Limited); "Matriculation Chemistry," by Temple Orme (Lawrence and Bullen); "An Elementary Manual of Applied Mechanics," by Prof. A. Jamieson (Charles Griffin and Co.); and a new work on practical physics, by Prof. W. F. Barrett (Percival and Co.).

Atmospheric Electricity.—*La Lumière Electrique* announces that M. André, well known for his researches on atmospheric electricity, which have been published in these columns, has met with a serious balloon accident. On Wednesday, the 28th ult., M. André made an ascent in a balloon called the *Espérance* with an assistant and an æronaut, his object being to make electrical observations in mid air, for which purpose he shipped 200lb. weight of apparatus. The ascent took place in a high wind and with insufficient ballast. Half an hour afterwards, when about 25 miles from Lyons, it became necessary to descend. The car was dragged along the ground about two miles before it could be stopped, and M. André sustained considerable injury. He will, however, shortly resume work.

Worcester.—At a meeting of the Watch Committee on Saturday last the Town Clerk reported that the Severn Conservators would oppose the proposal to utilise water power at the Diglis Weir for the purposes of the electric light. A letter had been received offering to grant a lease for 99 years of the Powick Mills at £160 per annum, or to sell the building for £5,000, in either case keeping up the weir. A letter was considered from the Brush Company giving details as to the best mode of utilisation of the water at Powick Mills. The sub-committee were of opinion that the proposal to utilise the water power at Diglis should be abandoned, but that the suggestion for placing the generating station at Powick Mills was worth serious consideration, and the surveyor was directed to report on the power likely to be derived from the Teme, and as to the possibility of navigating the Teme up to the mills.

Societies' Meetings.—Meetings of the Institution of Mechanical Engineers will be held on Wednesday and Thursday, October 26th and 27th, at 25, Great George-street. The chair will be taken at 7:30 each evening by Dr. William Anderson, F.R.S. The following Papers will be read and discussed as far as time permits:—"Second Report of the Research Committee on the Value of the Steam Jacket," "Experiments on the Arrangement of the Surface of a Screw Propeller," by Mr. William George Walker.—The first ordinary meeting of the Second Session of the Institution of Mining and Metallurgy will take place on Wednesday next at 8 o'clock in the Lecture Theatre of the Geological Museum, Jermyn-street. After an address from the President, Mr. H. M. Becher's Paper on "Mining in the Malay Peninsula: a Field for Mechanical Appliances, Hydraulics, and Electrical Transmission of Power," and Lieutenant Walter Bassett's Paper on "Auriferous Iron Sands and the Methods of Extracting Gold Therefrom" will be discussed.

Manchester.—At the last meeting of the Town Council a member said that he wished to ask, on behalf of a number of ratepayers who had already completed their installations, when they might expect to have the electric light? Alderman Sir J. J. Harwood stated, in reply, that there were difficulties in the way that the gas committee had not at first anticipated. One was the erection of a large chimney, the completion of which could not be hurried without risk to the stability of the structure. Another was that a large room was being lined with glazed bricks, and there was delay in the supply of the material. He might add that everything was being done that could be done, and there was no unnecessary delay. The mains were being laid in the streets in a very efficient manner, and the wires would be ready by the time of the completion of the other works. Possibly that would be soon after Christmas; he was inclined to think it would be in March or April. In addition to the matters he had mentioned there were conflicting interests between contractors which kept back the work at the electric light station.

The City Lighting.—At the meeting of the Commissioners of Sewers on Tuesday last, the Streets Committee recommended that the sum of £1,211. 15s. 7d. should be paid to the City of London Electric Lighting Company for lighting certain of the public ways of the City up to June 30th last, without prejudice to the contracts and Provisional Orders. This was agreed to after some discussion. The Clerk then read a letter from the Electric Lighting Company, asking permission to use some of their pipes for telephone cables. It was moved that the communication should be referred to the Streets Committee. Mr. A. A. Wood, A.K.C., F.C.S., was of opinion that, although the letter might be referred to the consideration of a committee, the Court should emphatically express their objection to the way in which this work had been done. It was, to his mind, exceedingly unbecoming for the Company to lay pipes without the knowledge or consent of the Court. Mr. A. C. Morton, M.P., wished to know why the Company had not approached the Court before laying the tubes. An amendment was moved and seconded to the effect that the consideration of the matter should be adjourned pending the carrying out of the Company's contracts. Mr. Bridgman reminded the Court that the National Telephone Company made a similar application some time ago, but it was refused. He considered that the City of London Company had stolen a march upon the other company. Mr. Shaw, having referred to the action the Court took in the matter of overhead wires about twelve years ago, said if there had been any trickery, as had been suggested by some speakers, he would not defend those concerned, but he thought the Court should, if they were able, make the persons pay for the concessions they had availed themselves of. The amendment was finally voted upon, and rejected by a large majority.

Flexible Metallic Tubing.—In a Paper recently read before the Society of Arts, Mr. Gilbert R. Redgrave, Assoc. Inst. C.E., described an ingenious form of flexible metallic tubing evolved by M. E. Levavasseur, of Paris. Satisfactory specimens have been turned out of a spirally-wound tube, made of thin metal strips of a peculiarly corrugated section, in which perfectly tight joints have been secured by simple interlocking of the coils of metal, without packing of any kind. Tubing of this kind has been employed at the Naval Exhibition to carry steam at 150lb. pressure; it has also been supplied to a leading railway company to carry petroleum gas at 200lb. pressure, and it has been applied with success to the pumping of petroleum oil. Mr. Redgrave suggested that the tubing was applicable as an armoured sheathing for telegraph, telephone, electric light, and submarine cables (shore ends). Some details respecting the weight of the tubing were given. The $\frac{5}{16}$th inch tubing, at present the smallest size made, weighs 2½oz. per lineal foot, ½in. 4oz. per foot, ¾in. 8½oz. per foot, 1in. 11oz. per foot, 1½in. 17oz. per foot. The $\frac{5}{16}$th and ⅜th inch sizes have been tested up to 2,700lb. per square inch of hydraulic pressure, the ½in. diameter tubing has withstood 2,000lb. per square inch; the larger sizes carry a gradually decreasing pressure down to 1,500lb. per square inch for the 1in. tubing. In the discussion which followed the reading of the Paper, Mr. C. U. Gray doubted whether the tubing would be used for electrical purposes. The shore end of a submarine cable was subjected to very rough usage on a rocky shore; and if the tube got fouled by any rock or projection, it might open up the metal. To cover an ordinary cable with a tube of the kind seemed to him somewhat risky. Though the tube might be perfectly tight, it would be impossible with so many joints in a long length to prevent moisture, and gas, permeating into the cable and destroying the insulating material. Again, by bringing two metals together which had been subjected to a strain for some time, so that they were in a distinctly different molecular condition, an electrical action which would corrode and wear the joints might be set up. Mr. H. Edmunds said the ordinary stranded wire armour had the disadvantage that the strands being parallel there was an opportunity for anything to pierce in between the strands. Any hard solid metal, such as iron or copper, was not flexible, and lead was too soft; but this flexible tube seemed to afford a solution of the problem. He did not know that it would be particularly applicable for the shore ends of submarine cables unless further protected by wire strands; but if for wiring a building, it would be very serviceable.

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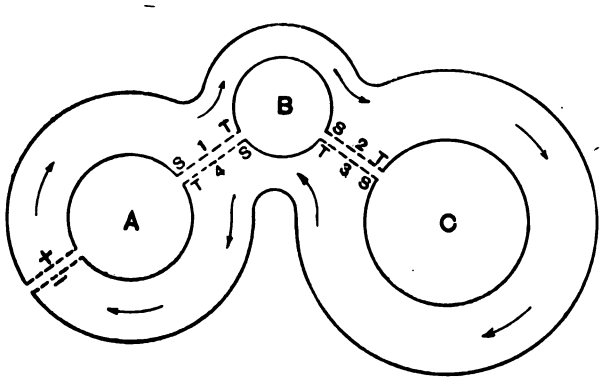
TO DRAW A MERCATOR CHART ON ONE SHEET, REPRESENTING THE WHOLE OF ANY COMPLETELY CONTINUOUS CLOSED SURFACE.

BY LORD KELVIN, P.R.S.

If a solid is not pierced by any perforation, its surface is called simply continuous, however complicated its shape may be. If a solid has one or more perforations or tunnels,* its whole bounding surface is called "complexly continuous;" duplexly when there is only one perforation; $(n+1)$-plexly when there are n perforations. The whole surface of a group of n anchor rings (or "toroids") cemented together in any relative positions is a convenient and easily understood type of an $(n+1)$-plexly continuous closed surface. Let the diagram represent a quadruplexly continuous closed surface made of very thin sheet metal, uniform as to thickness and homogeneous as to quality throughout. To prepare for making a mercator chart of it, cut it open between perforations C and B, B and A, A and outer space, in the manner indicated at $\frac{2}{3}$, $\frac{1}{4}$, and $\pm$. Apply infinitely conductive borders to the two lips separated by the cut at $\pm$, and apply the electrodes of a voltaic battery to these borders. By aid of movable electrodes of a voltmeter trace on the metallic surface a very large number $(n-1)$ of equidifferent equipotential closed curves between the + and − borders. Divide any one of these equipotentials† into parts each equal to the infinitesimal distance perpendicularly across it to the next equipotential on either side of it, and through



the divisional points draw curves cutting the equipotentials at right angles. These curves are the stream lines. They and the $(n+1)$ closed equipotentials (including the infinitely conductive borders) divide the whole surface into $n\,m$ infinitesimal squares, if m be the number of divisions which we found in in the equipotential. The arrows on the diagram show the general direction of the electric current in different parts of the complex circuit; each arrow representing it for the thin metal shell on either far or near side of the ideal section by the paper.

Considering carefully the stream lines in the neighbourhoods of the four open lips marked in order of the stream 1, 2, 3, 4, we see that for each of these lips there is one stream line which strikes it perpendicularly on one side and leaves it perpendicularly on the other, and which I call the flux-shed line (or for brevity the flux-shed), for the lip to which it belongs. The stream lines infinitely near to the flux-shed, on its two sides, pass infinitely close round the two sides of the lip and come in infinitely near to the continuation of the flux-shed on its two sides. Let F_1, F_2, F_3, F_4 (not shown on the diagram) be the points on the + terminal lip from which the flux-sheds of the lips 1, 2, 3, 4 proceed; and let G_1, G_2, G_3, G_4 be the points at which they fall on the − lip. Set S_1, T_1, S_2, T_2, &c., denote the points on the four lips at which they are struck and left by their flux-shed lines.

Let p_1, l_1, p_2, l_2, p_3, l_3, p_4, l_4, p_5 be the differences of potential from the + lip to S_1, from S_1 to T_1, T_1 to S_2, ... S_4 to T_4, and T_4 to the − lip. Measure these nine differences of potential. We are now ready to make the mercator chart. We might indeed have done so, without these elaborate considerations and measurements, simply by following the rule of my previous article; but the chart so obtained would have had infinite contraction at eight points, the points corresponding to S_1, T_1 ... S_4, T_4. This fault is avoided, and a finite chart, showing the whole surface on a finite scale in every part, is obtained, by the following process:—

Take a long cylindric tube of thin sheet metal, of the same thickness and conductivity as that of our original surface, and on any circle, H, round it mark four points, h_1, h_2, h_3, h_4, at consecutive distances along its circumference proportional repectively to the numbers of the m stream lines, which we find between F_1 and F_2, F_2 and F_3, F_3 and F_4, F_4 and F_1, on the + lip of our original surface. Through h_1, h_2, h_3, h_4 draw lines parallel to the axis of the cylinder.

Let now an electric current equal to the total current which we had from the + lip to the − lip through the original surface be maintained through our present cylinder by a voltaic battery with electrodes applied to places on the cylinder very far distant on the two sides of the circle H. Mark on the cylinder eight circles, K_1, K_2, ... K_8, at distances consecutively proportional to l_1, p_2, l_2, p_3, l_3, p_4, l_4, and absolutely such that l_1, p_1, &c., are equal to the differences of their potentials from one another in order. Bore four small holes in the metal between the circles K_1 and K_2, K_3 and K_4, K_5 and K_6, K_7 and K_8, on the parallel straight lines through h_1, h_2, h_3, h_4 respectively. Enlarge these holes and alter their positions, so that the altered stream lines through h_1, h_2, h_3, h_4 (these points, supposed fixed and very distant) shall still be their flux-sheds. While always maintaining this condition, enlarge the holes and alter their positions until the extreme differences of potential in their lips become l_1, l_2, l_3, l_4, and the differences of potential between the lips in succession become p_2, p_3, p_4. In thus continuously changing the holes we might change their shapes arbitrarily; but to fix our ideas we may suppose them to be always made circular. This makes the problem determinate, except the distance from the circle H of the hole nearest to it, which may be anything we please provided it is very large in proportion to the diameter of the cylinder.

The determinate problem thus proposed is clearly possible, and the solution is clearly unique. It is of a highly transcendental character, viewed as a problem for mathematical analysis; but an obvious method of "trial and error" gives its solution by aid of electric measurement, with quite a moderate amount of labour if moderate accuracy suffices.

When the holes have been finally adjusted to fulfil our conditions, draw, by aid of the voltmeter and movable electrodes, the equipotentials, for p_1 above the greatest potential of lip 1, and for p_5 below the least potential of lip 4; and between these equipotentials, which we shall call f and g, draw $n-1$ equidifferent equipotentials. Draw the stream lines making infinitesimal squares with these according to the rule given above in the present article. It will be found that the number of the stream lines is m, the same as on our original surface, and the whole number of infinitesimal squares on the cylinder between f and g is $m\,n$. Cut the cylinder through f and g; cut it open by any stream line from f to g; and open it out flat. We thus have a mercator chart bounded by four curves cutting one another at right angles and divided into $m\ n$ infinitesimal squares corresponding individually to the $m\,n$ squares into which we divided the original surface by our first electric process. In this chart there are four circular blanks corresponding to the lips 1, 2, 3, 4 of our diagram, and there is exact correspondence of their flux-sheds and neighbouring stream lines, and of the disturbances which they produce in the equipotentials, with the analogous features at the lips of the original surface as cut for our process. The solution of this geometrical problem was a necessity for the dynamical problem with which I have been occupied, and this is my excuse for

* A "hole" may mean a deep hollow, *not* through with two open ends. The word "tunnel" is inappropriate for the aperture of an anchor ring. Neither "hole" nor tunnel being unexceptionally available, I am compelled to use the longer word, "perforation."

† Two sentences of my previous article ("Generalisation of Mercator's Projection") in § 3, and in last paragraph but one are manifestly wrong, and must be corrected to agree with the rule given for dividing into infinitesimal squares, in the present text.

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working it out; though it might be considered as devoid of nterest in itself.

Errata.—"Generalisation of Mercator's Projection Performed by Aid of Electrical Instruments." In the last sentence of the fourth paragraph of this article, which appeared on page 553 of our issue of September 23, *for* "three" *read* "two." For corrections in Section 3, and in last paragraph but one, see the present article.

PROPAGATION OF THE CURRENT IN A CABLE CONTAINING DISTRIBUTED STATIC CAPACITY AND SELF-INDUCTION.*

BY FREDERICK BEDELL, PH.D., AND ALBERT C. CREHORE, PH.D.

(*Concluded from page 621.*)

Circuits with no Self-Induction.

When the effect of self-induction is not considered in the cable, we may put $L=0$ in the current and potential equations (22) and (21), and reduce them to more simple forms, thus

$$e = E\epsilon^{\pm\sqrt{\frac{CR\omega}{2}}x}\sin\left\{\omega t \pm \sqrt{\frac{CR\omega}{2}}x\right\} \quad . \quad . \quad . \quad . \quad (23)$$

$$i = \mp E\sqrt{\frac{C\omega}{R}}\,\epsilon^{\pm\sqrt{\frac{CR\omega}{2}}x}\sin\left\{\omega t \pm \sqrt{\frac{CR\omega}{2}}x + 45^\circ\right\} \quad (24)$$

These results agree with those given by Mr. T. H. Blakesley in his book on "Alternating Currents of Electricity," page 60, Second Edition. They may be directly obtained from the differential equation ($8\frac{1}{2}$), and upon differentiation will be found to satisfy it.

Nature of the Wave Propagation.—Equation (23) shows that at any point of the conductor the potential varies harmonically with the time. At the origin, where $x=0$, the potential is always equal to $e=E\sin\omega t$, its maximum value being E; but, as we proceed from the origin, the potential becomes less, being equal to $E\epsilon^{-\sqrt{\frac{CR\omega}{2}}x}$ an expression which decreases as x increases. The double sign is retained in the exponent in the equation, since it represents two waves, one going in the positive and the other in the negative direction from the origin, which is the source of alternating potential. The maximum value of the potential at any point of the cable may be represented as in Fig. 2 by an ordinate to the logarithmic curve. Thus, $\overline{0A}$ represents the maximum value of the harmonically varying potential at the origin, and $\overline{BC}$ its maximum value at a distance x, from the origin. The distance $\overline{0B}$ is taken as that in which the logarithmic curve has decreased to $1/\epsilon$th of its original value, $\overline{0A}$. The distance $\overline{0D}$ is a quarter wave-length, and $\overline{0E}$ a half wave-length. It will be presently shown that the amplitude decreases to almost $\frac{1}{500}$th of its original value in one complete wave-length.

One of the most striking results shown by these formulæ is that the current always precedes the potential by one-eighth of a period, and this difference in phase is not altered by any change in the resistance or capacity of the cable.

Rate of Propagation.—Curve I. (Fig. 2) represents an instantaneous position of the potential wave travelling along the wire in each direction from the origin. The distance along the cable from one maximum potential to the next, or in other words, the length of one complete wave, may be found by equating to 2π the angle containing x in the equation. This gives

$$\sqrt{\frac{CR\omega}{2}}x = 2\pi,$$

or,

$$x=\lambda=2\pi\sqrt{\frac{2}{CR\omega}}=2\sqrt{\frac{\pi}{CRn}},$$

where λ denotes the length of one complete wave, and $n\left(=\frac{\omega}{2\pi}\right)$ the frequency of alternation.

The time of one complete period is represented by $T=\frac{1}{n}$, and in that time the wave advances a distance λ, equal to one wave-length. The rate at which the wave advances is found by dividing the wave-length by the time taken in advancing that distance; thus—

Rate of propagation $=\frac{\lambda}{T}=2\sqrt{\frac{n\pi}{CR}}=\sqrt{\frac{2\omega}{CR}}$. It is seen that the rate of propagation not only depends upon the character of the cable, but likewise varies as the square root of the frequency of alternation. A wave with a frequency of 400 will travel twice as fast as one with a frequency of 100 alternations per second.

Decreasing Amplitude.—The frequency not only affects the rate of propagation but it also has a marked influence upon the rate at which the amplitude of the waves decreases with

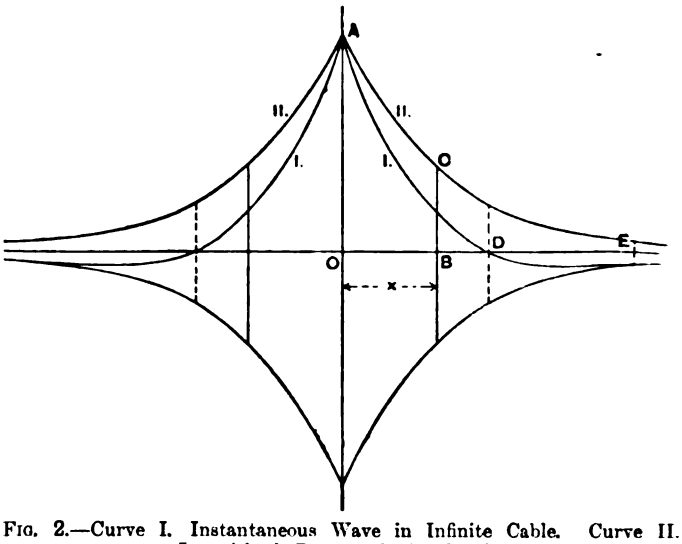

FIG. 2.—Curve I. Instantaneous Wave in Infinite Cable. Curve II. Logarithmic Decrease in Amplitude.

the distance. The distance, which we will call x, at which the amplitude of the wave will have $1/\epsilon$th of its original value, is the reciprocal of the coefficient of x in the exponent; thus—

$$x'=\sqrt{\frac{2}{CR\omega}}.$$

This distance, at which the wave decays to $1/\epsilon$th of its value at the origin, varies inversely as the square root of the frequency; this means that a wave with a frequency of 100 alternations per second can go twice as far as one with a frequency of 400 and experience the same decay in amplitude. Comparing this value of x' with that of a wave-length λ, we may write

$$x'=\frac{\lambda}{2\pi}.$$

The amplitude of a wave, therefore, decreases to $\frac{1}{\epsilon^{2\pi}}=0{\cdot}00187$ of its value in advancing a distance equal to one wave-length.

In order to find the time t^1, in which the amplitude decays to $1/\epsilon$th of its value, we must divide this distance, x^1, by the rate of propagation; thus:—

$$t^1=\frac{\frac{\lambda}{2\pi}}{\frac{\lambda}{T}}=\frac{T}{2\pi}=\frac{1}{\omega}.$$

We see that the time of decay varies inversely as the frequency; thus, a wave with a frequency of 400 alternations per second will decrease a certain amount in one-fourth the time a wave with a frequency of 100 is decreasing the same amount.

* From a forthcoming work on "Alternating Currents." (The W. J. Johnston Co., New York.) All rights reserved.

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Circuits with Self-Induction.

It will be noticed that the introduction of self-induction into the cable in the manner before described does not materially alter the character of the wave propagation. This is evident from the equations (21) and (22). At every point of the conductor, the potential, or current, varies harmonically with the time and, as before, the amplitude of the wave decreases with a logarithmic decrement as it proceeds from the origin.

Phase Difference.—One effect of the self-induction is to change the angle of advance of the current ahead of the potential. Thus, angular difference is no longer a constant angle of 45°, as formerly, but is a function depending upon R L and ω, viz :—

$$\tan\theta = \sqrt{\frac{Im - L\omega}{Im + L\omega}} = \frac{P}{a}. \quad . \quad . \quad . \quad (25)$$

When $L = 0$, $\tan\theta = 1$, and $\theta = 45°$. As L increases from zero to infinity, the expression changes from unity to zero, and the angle θ, consequently from 45° to 0°. The effect of the self-induction is, therefore, to decrease the phase difference between the current and potential. This difference of phase also becomes less with an increase in the frequency.

Rate of Propagation.—The distance along the cable between two maxima is found by equating the angle containing x in equation (21) to π and solving for x, thus—

$$x = \lambda_1 = \frac{2\pi}{a} = \frac{2\pi\sqrt{2}}{\sqrt{C\omega}\sqrt{Im + L\omega}},$$

where λ denotes the wave-length. Subscripts are here used to denote circuits with self-induction. The time occupied in travelling this distance is $T = \frac{2\pi}{\omega}$; hence

$$\text{rate of propagation} = \frac{\lambda_1}{T} = \frac{\omega}{a} = \sqrt{\frac{2\omega}{C\{Im + L\omega\}}}.$$

It is noticed that the wave-length and the rate of propagation are each less than that found for circuits containing no self-induction. When $L = 0$ the expressions just found reduce to those previously given.

Another point to be noticed is that a change in frequency will have a greater effect in altering the wave-length, and not so great an effect in changing the rate of propagation as in the case of a circuit with no self-induction. Two waves of different periods will, therefore, go more slowly, but with less difference in their rates of propagation than with no self induction. As before, the wave of higher frequency will have the shorter wave-length and advance the faster.

Decreasing Amplitude.—As before, the amplitude of the harmonic wave has a logarithmic decrement, decreasing with the distance from the origin. The distance at which the amplitude has 1/ϵth of its original value is the coefficient of the exponent; thus,

$$x'_1 = \frac{1}{p} = \frac{\sqrt{\frac{2}{C\omega}}}{\sqrt{Im - L\omega}}.$$

This is larger on account of the self-induction. The substitution of $L = 0$ reduces it to the value of x^1 found before. An increase in frequency will cause this value to decrease, and the decay in a certain distance to increase; but the frequency has not so great an influence upon this decay as it has in a circuit with no self-induction.

Comparing with the values found for λ, and θ, we see that

$$x'_1 = \frac{\lambda_1}{2\pi\tan\theta}.$$

In order to find the time t'_1, in which the amplitude decays to 1/ϵth of its original value, we divide the distance x'_1, by the rate of propagation; thus—

$$t' = \frac{\frac{\lambda_1}{2\pi\tan\theta}}{\frac{\lambda_1}{T}} = \frac{T}{2\pi\tan\theta} = \frac{1}{\omega\tan\theta},$$

The self-induction causes $\tan\theta$ to have a value less than unity, thus increasing the time for a certain decay—that is, decreasing the rate. An increase in the frequency causes θ to become smaller. The exact effect upon the rate of decay caused by a variation in frequency in a circuit with self-induction depends upon the constants of the circuits. The wave of higher frequency will always decay the more rapidly, but with self-induction in the circuit there is less difference in the rates of decay of waves of different periods than there is in circuits without it.

Limitations of the Telephone.—The effects of distributed capacity in a conductor upon the wave propagation have been given, and the way in which these effects are altered by the introduction of self-induction or by a change in frequency. A consideration of the results with reference to telephone circuits is valuable, inasmuch as it is just such effects that cause the limitations to telephony. In all cases the waves of higher frequency travel the faster, and so the several harmonic components of a complex tone are constantly changing in their relative phases. The waves of higher frequency are likewise subject to the more rapid decay, and so when the several components are recombined the resultant tone may be materially altered from the original complex tone. These effects may be modified by the presence of self-induction, but in all cases they will be present to a certain extent, thus defining the limits of the use of the telephone.

Wave Propagation in Closed Circuits.

Let us consider that a dynamo giving an harmonic alternating E.M.F. is inserted at some point of a cable, such as that described, which forms a continuous closed circuit. There will be a forward wave of positive potential starting from one pole of the machine which will travel around and around the circuit continually, diminishing in amplitude until it finally vanishes. At the same time a backward wave of negative potential starts from the other pole of the machine, and travels around in the opposite direction until it, too, vanishes. The potential at any particular point of the circuit is thus the sum of the potentials due to all the positive and negative waves. Let l denote the length of the cable. When the first positive wave reaches a point at a distance x from the pole of the dynamo the potential due to the forward wave is—

$$e_{F_1} = E\,\epsilon^{-px}\sin(\omega t - a x).$$

where p and a have the values given in (19) and (20). When the wave has travelled completely around the circuit, and comes to this point a second time, its value is,

$$e_{F_2} = E\,\epsilon^{-px-pl}\sin(\omega t - a x - a l),$$

which may be obtained by substituting $x + l$ for x in the above. After going n times around the circuit it has become

$$e_{Fn} = E\,\epsilon^{-px-pln}\sin(\omega t - a x - a l n).$$

The resultant of all these forward waves at any one point may be written, therefore,

$$e_F = e + e_{F_2} + \ldots\ldots e_{F\infty} = E\epsilon^{-px}\sum_{n=0}^{n=\infty}\epsilon^{-pln}\sin(\omega t - a x - a l n) \quad . \quad (26)$$

When we consider all the backward waves, we may represent them by a similar expression in which E has the negative sign. When the first backward wave has travelled around the circuit so as to be a positive distance x, from the origin it has gone a distance $l - x$; this distance from the origin in a negative direction we will call x'. For the first backward wave we may then write

$$e_{B_1} = -E\,\epsilon^{-px'}\sin(\omega t - a x'),$$

and for the sum of all the backward waves,

$$e_B = -\epsilon^{-px'}\sum_{n=0}^{n=\infty}\epsilon^{=pln}\sin(\omega t - a x' - a l n) \quad . \quad . \quad (27)$$

These expressions (26) and (27) may be simplified, since we may put—

$$\sin(\omega t - a x - a l n) = \sin(\omega t - a x)\cos a l n - \cos(\omega t - a x) \times \sin a l n \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

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Substituting (28) in (26), we have—

$$e_F = E\epsilon^{-px}\sin(\omega t - a x)\sum_{n=0}^{n=\infty}\epsilon^{-pln}\cos a l n - E\epsilon^{-px}\cos(\omega t - a x)\sum_{n=0}^{n=\infty}\epsilon^{-p n}\sin a l n \quad . \quad (29)$$

Similarly we may reduce (27) to (30)—

$$e_B = -E\epsilon^{-px'}\sin(\omega t - a x')\sum_{n=0}^{n=\infty}\epsilon^{-pln}\cos a l n + E\epsilon^{-px'}\cos(\omega t - a x')\sum_{n=0}^{n=\infty}\epsilon^{-pln}\sin a l n \quad . \quad (30)$$

The resultant potential at any point due to the forward and backward waves is the sum of E_F and E_B. Writing $l - x$ for x' in (30), and adding to (29) we obtain—

$$e = E\sum_{n=0}^{n=\infty}\epsilon^{-pln}\cos a l n\cdot\left\{\epsilon^{-px}\sin(\omega t - a x) - \epsilon^{+px-pl}\sin(\omega t + a x - a l)\right\} + E\sum_{n=0}^{n=\infty}\epsilon^{-pln}\sin a l n\cdot\left\{\epsilon^{+px-pl}\cos(\omega t + a x - a l) - \epsilon^{-px}\sin(\omega t - a x)\right\} \quad . \quad . \quad . \quad . \quad (31)$$

By means of the exponential values of the sine and cosine, the values of the two summations expressed in (31) are found to be

$$\sum_{n=0}^{n=\infty}\epsilon^{-pln}\sin a l n = \frac{\epsilon^{pl}\sin a l}{1 - 2\epsilon^{pl}\cos a l + \epsilon^{2pl}} \quad . \quad . \quad . \quad . \quad (32)$$

and

$$\sum_{n=0}^{n=\infty}\epsilon^{-pln}\cos a l n = \frac{\epsilon^{2pl} - \epsilon^{pl}\cos a l}{1 - 2\epsilon^{pl}\cos a l + \epsilon^{2pl}} \quad . \quad . \quad . \quad . \quad (33)$$

Let P O P (Fig. 3) represent the cable which is supposed to form a closed conductor, the ends at P being joined together. The maximum value of the potential at the positive pole of the dynamo is represented by $\overline{OA}$. As we go from A this decreases along the logarithmic curve A B C D E until it finally vanishes altogether. Similarly a backward wave coming from the negative pole decreases along the curve A' B' C' D' E'. At the point P, half-way between the poles of the dynamo, the middle point of the cable, it is evident that the potential remains continually zero; for at the point P the distance x is $\frac{l}{2}$, which value reduces equation (31) to zero.

If the length of the cable happens to be some multiple of a wave-length, the expression for the potential takes a simpler form. In this case each successive forward wave travels around the circuit in the same phase as the first, and all these forward waves may, therefore, be added together algebraically. The maximum resultant potential at any point will be the sum of the maxima of all the separate waves. In Fig. 3 e_{F1}, e_{F2}, represent successive forward, and e_{B1}, e_{B2} the corresponding backward waves. In the case where the cable is some multiple of a wave-length, the sum of the maxima of all the forward and of all the backward waves are represented by the dotted lines e_F and e_B respectively. The solid e, the sum of e_F and e_B, represents the resultant maximum potential along the conductor.

We have seen that the wave-length is $\lambda = \frac{2\pi}{a}$. When the cable is a multiple of a wave-length, $l = \kappa\lambda = \frac{2\pi\kappa}{a}$, and, therefore, $a l = 2\pi\kappa$. This value of $a l$ reduces equation (32) to zero, since $\sin 2\pi\kappa = 0$, and reduces (33) to

$$\frac{\epsilon^{p} - 1}{(1 - \epsilon^{pl})^2}.$$

These values cause the second term in (31) to vanish and the whole then becomes

$$e = E\frac{\epsilon^{px} - \epsilon^{pl-px}}{1 - \epsilon^{pl}}\sin(\omega t - a x),$$

which expresses the resultant potential, represented by the solid line e in Fig. 3, at any point of the cable, provided its length is some multiple of a wave length. When $x = 0$, this reduces to $e = E\sin a t$, the expression for the potential at the terminals of the dynamo. When $x = l/2$, the expression vanishes, showing that the potential is constantly zero at the middle point of the conductor. This last simplification was made possible by considering the length of the cable to be a multiple of the length of wave. Otherwise the algebraic addition of the maxima of the several waves would not be possible, since they would differ in phase. The construction of the resultant curves would not be so simple, but the nature of the results would not be materially modified. The phenomena in connection with the flow of current are similar, and are obtained in the same manner from the current equation.

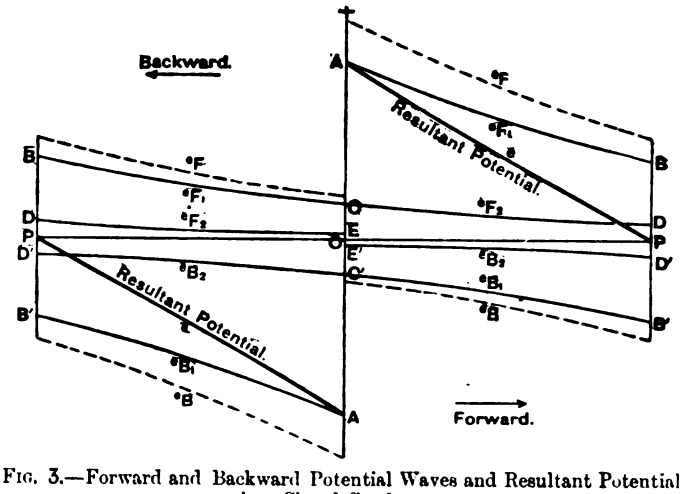

FIG. 3.—Forward and Backward Potential Waves and Resultant Potential in a Closed Conductor.

CABLE RELAYS.

BY WALTER JUDD.

I have been much interested in the recent communications to the electrical journals on the subject of cable relays. The cable relay is an instrument which has been, I suppose, the dream of cable managers and electricians for years, and one that has seriously occupied the minds of many of us. It may be interesting to those who have experimented in this direction if I shortly recount the experiments made in Hong Kong during the last five years.

The first idea that occurs to any experimenter is naturally a relay with fixed contacts; but, as Mr. Cuttriss says, the "sticktion" is fatal to success. In 1887 I endeavoured to vary the resistance in a local circuit by including in it a high resistance plunger dipping into a conducting solution, the resistance varying with the length of plunger out of the fluid somewhat as shown in Fig. 1, P being the plunger raised and lowered by the recorder

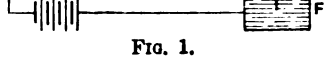

FIG. 1.

coil, I the local instrument, B battery, F the conducting fluid. I tried porous earthenware, carbon rods of high resistance, also compounds of Portland cement and plaster of Paris with plumbago and powdered carbon but found that a thin strip of ordinary paper gave the best results. I then tried thin elastic threads coated with powdered carbon or plumbago, obtaining the variation of resistance by the amount of extension produced by the movement of the recorder coil. Microphonic contacts of two carbon points were also tried but given up as impracticable, the range between perfect contact and infinity being too small and variable. All the above methods were tried in 1887 and 1888, but it was found that the principle sketched

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above involved a current being always in the local instrument, the movement being obtained by increments and decrements of the current passing, rendering adjustment and fixed zero difficult to maintain. In 1889, in consequence of this difficulty, I adopted the bridge method, and from that date to this experiments have been carried out. I reverted to the plumbagoed elastic threads, but was unable to obtain good contacts, and therefore returned to the water resistance.

The experiments have all been carried out with an ordinary recorder, the aluminium siphon cradle being used as the pointer to be moved in the trough. At first the connections were thus (Fig. 2). The current from the battery all passed into the water trough T by the plunger or pointer P, and the current density, owing to the small surface, about 4 millimetres, caused immediate bubbling. To obviate this, the current was commuted into an alternating current, and redressed by another commutator in the galvanometer circuit, thus (Fig. 3).

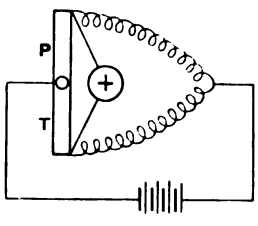

Fig. 2.

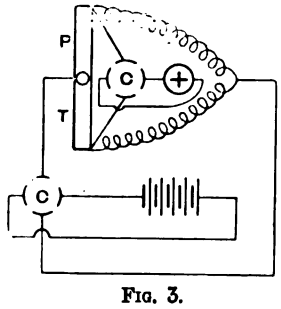

Fig. 3.

The two commutators CC were mounted, of course, on the same shaft, and it was found that, owing to the counter electromotive force set up in the water trough T, there was a slight lag and the commutator brushes had to be adjusted accordingly. The alternating current certainly diminished the trouble due to gas bubbling, but it was found still to occur when the current had passed for some considerable time, and by gathering round the pointer P the bubbles held it so fast as to almost destroy its movement. The next change was to make the connections so that the pointer only had to carry the current in the galvanometer circuit (Fig. 4). This effected a great improvement, and certainly reduced the bubbling.

We then dispensed with the commutator, and made a trough with large electrodes. In plan the trough was as in Fig. 5. A and B are circular holes, about $\frac{3}{4}$in. in diameter, in a slab of ebonite, joined by a narrow trough. A and B are lined with lead, and connected to suitable terminals. The whole system

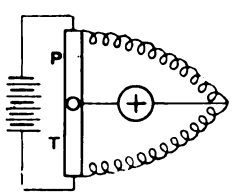

Fig. 4.

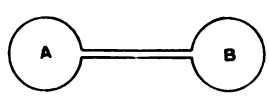

Fig. 5.

is then filled with liquid, and thus forms two arms of a bridge. With a considerable direct current we found that the bubbling became apparent after several hours, and evidently either larger electrodes or some depolarising compound was required. This it is difficult to use without at the same time making the liquid too conducting.

Matters were in this stage when we heard of Mr. Cuttriss's charming plan of spiral carbons (*The Electrician*, June 10, p. 147). If this works, then most undoubtedly in my opinion it is the best. Electrolytes are always variable, and they also evaporate, while carbon, once adjusted, should remain very fairly constant. I congratulate Mr. Cuttriss on his ingenious device, and trust that now attention is called to the subject the cable relay will soon be a *fait accompli*. The double differential system proposed by Mr. Raymond Barker in your contemporary, the *Electrical Review*, can easily be applied to the carbon spring method, and will, of course, make it more sensitive.

Now, one word as to its use when perfected. I think that it is hopeless to relay from one cable to another unless the cables are very short. For long cables I do not believe in the possibility of obtaining impulses sufficiently clear and distinct to operate any dead beat relay, which would be required to actuate signalling levers. If it could be done, the apparatus would be so delicate and complicated that it could never be left to itself, and if an experienced man is to be in attendance, it is far better to let him be the translator, as in Mr. Smith's human relay method. I have all along looked to a relay as a means of doing away with the siphon and the friction against the paper, which takes place at every vibration, and so obtaining a sharper and more defined movement reproducible upon a simpler and less sensitive local instrument. Any one who will watch the movement of the siphon cradle when the siphon is off cannot fail to see the gain in definition. This applies only, or principally, to long cables, and I imagine that a gain in speed of 10 to 20 per cent. can be realised by a good relay—an enormous advantage in every way. In common with all who are interested in cables, I wish every success to the ingenious inventors who have brought this much desired improvement within the sphere of practical teletics.

A DIFFERENTIAL VOLTMETER.

For the purpose of testing the drop in a Hedgehog transformer, run from a gas engine or unsteady steam engine, Mr. Swinburne has designed an ingenious instrument, which enables accurate measurements to be made in spite of considerable variations of speed in the dynamo. We reproduce a

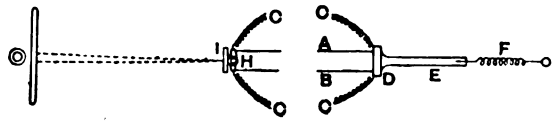

diagram of the instrument from *Industries*. The object is to measure a small change of voltage. If one voltmeter only were used, it would follow all the fluctuations of speed and accurate readings would be out of the question; a differential Cardew voltmeter is therefore employed. This is alluded to in the article, as is the fashion amongst some writers, as a hot-wire voltmeter.

To obtain a standard, the primary coil of a closed circuit transformer was used as resistance, and this was tapped at two places, between which there was a difference of potential of 100 volts at the average speed of the engine, but owing to fluctuations this voltage would not be steady. These volts were measured by one of the wires of the differential voltmeter, the other being used for measuring the voltage of the Hedgehog under test. When the speed, for example, dropped a little, both parts of the differential voltmeter would be equally affected, but any difference in the voltage of the two circuits would be indicated by a steady deflection of the instrument. In the diagram A and B are the two hot wires, and these are connected at one end to the block D of ivory, having a long tail-piece E, kept taut by a spiral spring F. The other ends of these wires are attached to a short lever, H, which carries a mirror, I; flexible connections are provided between the wires A and B and the terminals C. The instrument is said to be very sensitive, reading to within a small fraction of 1 per cent. The drop of the transformer was thus accurately determined, although the speed of the engine was varying considerably. In view of the great difficulty of getting accurate readings when testing dynamos or other electrical apparatus driven from gas engines or other unsteady sources of power, Mr. Swinburne's differential arrangement seems to offer considerable advantages.

Electric Tramway in the Tyrol.—It is intended to build an electric tramway between Riva and Pinzolo. The line will be 26 miles in length.

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The Electrician.

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OCTOBER, 1878.

We estimate past history in decimals. Once, by the decade and lustrum, and now, by centuries, or by generations the third of a century. But in measuring the history which is yet to come, the favourite unit is seven. The perfect number is chosen by the surveyor who fixes his inaccessible points out into the dim future. Leases are commonly made out in seven, fourteen or twenty-one years, and penal servitude is meted out in the same units. Seven years is the limit of a Parliament. Twenty-one years was the duration of the first stage of existence for electric supply companies, proposed by Mr. CHAMBERLAIN, and afterwards extended by no septennial increment, but by the factor 2. In the Statute of Monopolies a term of twenty-one years is mentioned, but for the future it was enacted that the duration of a patent should be fourteen years. Glancing back fourteen years takes us, then, to the genesis of those patents which are now expiring, and probably no period in the history of electric lighting showed greater inventive activity than October, 1878. The only electrical patent of importance in the early part of that year was dated May 18, No. 2,003, Brush's great compound winding patent; but several others of interest are to be found, *e.g.*, Wallace's arc lamp with flat carbons, No. 240, Miss Hosmer's magnetic engine Nos. 311, 2,930 and 3,676, and La Cour's phonic wheel, No. 1,988. Among the numerous arc lamp patents we find Werdermann, No. 2,477, which is worthy of mention, since an arrangement of lamps in parallel circuit with two-way switches and equivalent resistances is described; a curious half-way stage between true parallel running and the equivalent resistance system of switching on series circuits. The

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negative main was doubled back upon itself, so that "the electric currents for all the lamps or lights will have to flow the same distance." In August we find the Obach galvanometer (No. 3,317), with inclined coil, and in the following month De Meritens (No. 3,658) patented his dynamo.

The series of electric lighting patents of October begins with No. 3,912 on the 4th, by W. S. Wilson, who proposed to improve the arc by "gas or vapour of sufficient conducting power, such as a metallic vapour or hydrocarbon," an idea which has been often re-invented. On the 9th M. Radcliffe Ward patented some doubtful improvements (No. 3,976) on the Gramme dynamo; on the same day, No. 3,985, Sir H. W. Tyler proposed the use of platinum or other gaseous liquid or solid materials to give a light, together with other sundry devices. The same day is memorable for No. 3,988, the Lane-Fox patent, which we need not describe. The problem of "the subdivision of the electric light" was in the air, and Lane-Fox's patent contained the first clear enunciation and practical solution of it, by constant voltage, low resistance mains, and high resistance lamps. On the same day, October 9, 1878, J. Clark filed an application, No. 3,991, for "adapting the electric light to domestic and other purposes." In this invention a bath of mercury was to be placed at the end of the main conductor, and from this a number of finer conductors, all preferably of uniform length and resistance, led to the lamps. Clark's first claim was for "the method of subdividing a strong current of electricity or magneto-electricity by passing it through a number of secondary wires of equal length and thickness, substantially as described." The lamps were made by enclosing finely-powdered charcoal in glass tubes, which were then surrounded by a larger globe. Here was parallel running from an "omnibus bar." On the next day S. Marcus, of Vienna, communicated his invention for "an incandescence lamp," but it seems to have been of the Werdermann type, a weighted carbon rod being pressed against the edge of a carbon disc. On the 11th came the first of a remarkable series of inventions for "division." No less than five times in the course of this month the same device, with trifling variations, was patented. J. Munro led the way with No. 4,016. A rapidly-revolving shaft was connected to one terminal of the generator, and the ends of all the lamp circuits "say a hundred, less or more," were arranged radially round this shaft. A brush contact swept round, making contact with every lamp in each revolution. The successive contacts were to be made so rapidly, 600 to 1,800 per minute, that no flicker would be perceptible. On the 5th of November, an appropriate day for fireworks, three more current dividers of exactly the same kind were patented. Several of the inventors seem to have imagined that so long as the lamp had not time to go out between the intervals of contact, so long, in fact, as it continued to burn while robbed of its current, there was an enormous economy. The Delany multiplex telegraph, invented long afterwards, is a singular application, in a correct and most useful form, of the principle of multiple contacts.

Returning to October, 1878, we find, after some miscellaneous inventions, Lane-Fox's second electric lighting patent, No. 4,043, in which he suggests enamelled wire for boiling water and heating, and switches for coupling secondary batteries. Passing over four more electric light patents we find two inventions of I. L. Pulvermacher, the first (No. 4,079) relates to a reflector of glass thinly coated with platinum, thus combining a translucent shade with a tolerable reflector. The efficiency of the arrangement was probably little better than opal glass, though it seemed attractive at the time. F. H. Varley followed with No. 4,100, in which carbon powder was fed on to the lower electrode of an arc lamp by a clockwork. On the next day (16th) came the third rotary divider, and an arc lamp (No. 4,116) of Prof. G. Forbes, in which the light was to be exhibited in flashes of extremely short duration by vibratory carbons points, or by a number of carbons on a rapidly revolving wheel. "At the present time," says the inventor in the specification, "the great obstacle to the progress of electric lighting is the difficulty in establishing any considerable number of lights in connection with one electric circuit." He admits that the intensity of the light "increases and diminishes with the number of flashes per second." Disregarding four patents, we come to unipolar dynamo, No. 4,206, by R. Paget Higgs, who was probably unaware that E. W. Siemens and F. H. von Alteneck had communicated a similar invention (No. 3,131) less than seven weeks earlier. No. 4,208 described an arc lamp by C. W. Siemens, and in No. 4,212 Sir Charles Bright patented the lighting of vacuum tubes by the secondary coils of an induction apparatus situated at each point where the light was required, the primary coils were to be coupled up to a main conductor common to them all. May this be freely interpreted as allowing a transformer to each house?

The next day, October 23rd, in No. 4,226, Edison's invention for "developing electric currents and lighting by electricity" was securely lodged at the Patent Office. His last British patent had been for an electric pen almost exactly three years before. Certain features of this invention burst upon an astonished world as the first of a long series of electric lighting marvels, whilst certain other features have been discreetly buried in oblivion. The platinum spiral with its automatic cut-out was talked about until hundreds of people believed and believe to this day that Edison "invented the electric light." The electrolytic meter still survives, but what shall we say of that magneto-electric-generator consisting of a huge tuning-fork carrying electro-magnets which were to wave in front of fixed magnets, the vibrations being maintained by a small air, gas, or steam engine, suitably connected to the end of each arm of the fork? "It has been known," he states in the specification, "that vibratory bodies such as a tuning-fork or reed can be kept in vibration by the exercise of but little power." Out of 68 illustrations, the first depicts the "very large tuning-fork," and the rest show different forms of the lamp and cut-out. It is easy to laugh at this monstrosity, but it stands as an interesting record of the mechanical and electrical measure of a man who was so soon afterwards to do so much. Edison took only one other British patent in 1878 for electric light, and three in 1879, but nine were applied for in the following year, while during 1881 they poured in at the rate of one a fortnight. Two days later, on October 25th, J. E. Stokes, of Upton Manor, Essex, described a light-emitting spiral surrounding a rod of metal, which by its expansion actuated a lever and cut the lamp out, exactly as detailed by Edison. The illustrations show even the same pattern of terminal post, a tapering pillar; and the coiled filament is precisely the same, and like Edison's is shown with ten turns, the loop at the end pointing upwards to the right. Seven more electric lighting patents bring us to No. 4,316 of Berthoud and Borel for their well-known lead-covered wire; and on the last day of the month we find an incandescence lamp by S. F. Van Choats, of New York (No. 4,388), in which the ribbon or spiral is formed of asbestos, mica, platinum, or carbon, or any combination of these—a near approach to a carbon lamp. Edison, however, was still busy with platinum until as late as June of the following year, and his carbon spiral was not patented until No. 4,576, on November 10, 1879. The nearest approach to

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it in 4,226 of 1878 was Fig. 7, which represents "a light-giving body formed of platina or similar wire, around which carbon is made to adhere by pressure." SWAN, on the other hand, who had long before this experimented with carbon filaments, did not apply for a patent until January 2, 1880. Our list ends with the fifth rotary current divider by T. A. BELL, of Liverpool, and a patent for heating by means of platinum or other wires.

Turning to our own columns, we find a short note of four lines, immediately before the leading article in our issue of October 5, 1878. It is there recorded that LANE-FOX's lamp-lighting in Pall Mall had been in successful operation for the last fortnight. After a leader on telegraphic education comes an article by Prof. AYRTON on "Single and Double Current Duplex Translation," dated from the Scientific Club, Savile-row. Fads were rife then as now, and Mr. DESMOND FITZ-GERALD contributes a long letter on British Association Units, advocating megafranks, franklinads, &c., and speaking of vebers and microjoulads. Reports of meetings of three Gas Companies are to be found at the end of this issue; the advent of electric light, meaning, of course, arc and Jablochkoff lamps, is eagerly and shrewdly discussed. Our next number, dated October 12th, contains an article by Mr. OLIVER HEAVISIDE on "The Resistance of Telegraphic Electromagnets"; EDISON's carbon rheostat; an article by Prof. OLIVER LODGE on Dr. GUTHRIE's electrolytic experiments; and an extract from the *New York Sun* announcing EDISON's marvellous discovery. The issue ends with four columns of gas companies' meetings, from which we are greatly tempted to make some interesting extracts. Our leading article on October 19, 1878, discusses "The Scare among the Gas Companies." The last number of *The Electrician* in this month is full of electric lighting. "Mr. Fox's" letter to *The Times* on the use of condensers for distributing and dividing the current is commented upon. An illustrated description of the Weston dynamo is given. A Paper by Profs. AYRTON and PERRY, dated April, 1878, from the Imperial College of Engineering, Japan, on "The Resistance of the Arc of the Electric Light," is reproduced from "the new *Journal* of the Society of Telegraph Engineers." This is followed by a further gushing account of EDISON's rash promises to the *New York Herald*. The leading article contains surmises on "The Nature of EDISON's Invention," and explains how "carbon has been universally adopted as the wick, so to say, of the lamp;" and this produced "an unsteady and flickering light. This variation in resistance is also the chief cause of failure of attempts to subdivide the electric light. . . . Mr. EDISON surmounts all these difficulties by avoiding them. He embeds the ends of the conducting wires into a broad flat cake of some substance that is unattacked by the atmosphere when raised to incandescence by the passage of the current across it. What this substance is Mr. EDISON has not yet told us." At the end of this number is a report on the electric light, submitted to the Metropolitan Board of Works, and a report of the discussion on the lighting of the Embankment and Waterloo-bridge by Jablochkoff lamps.

Although we have discussed at unusual length the electrical patents which came into existence just fourteen years ago, when as yet domestic electric lighting was in the clouds, we do not claim that during October, 1878, an extraordinary number were applied for. It is the importance of several that we have enumerated, and the evident tendency even of the worthless ones towards useful ends, the awakening of many to the need for dividing the current, and the inception of the glow lamp, that stamp this month as a notable epoch in the history of electric lighting.

REVIEWS.

Lightning Conductors and Lightning Guards. By OLIVER J. LODGE, D.Sc., F.R.S., LL.D., M.I.E.E. (London: Whittaker and Co.)

Five years ago lightning conductors were not a topic to conjure with. The exact nature of the "thunderbolt" and the best shape for a lightning rod and its terminals had, it is true, formerly excited the scientific curiosity of a Franklin and aroused even a Faraday and a Snow Harris out of their habitual equanimity. But at the beginning of 1888 the subject of lightning conductors was apparently as exhausted as an extinct volcano. Everything had been reduced to regular routine; given high conductivity, continuity and a good earth and something approximating perfect protection followed; at least, so said all the authorities. Iron indeed was preferred by some to copper, but on purely mechanical and commercial grounds. Moreover, the "protected area" had not as yet become quite crystallised. Some believed in Mr. Preece's "special cone" which had a radius at the ground equal to the height of the rod, with concave sides marked out in section by an arc of 90 deg. described from a point on either side at the level of the top of the rod and distant from it by its own length. Others inclined to Melsens' ordinary cone, which had a base radius equal to only half its height. Such was the orthodox faith up to the time of Dr. Lodge's Mann Lectures, delivered before the Socicty of Arts on March 10 and 17, 1888. It was an instructive instance both of the dead weight of *ex cathedrâ* utterances even in the realm of science where in theory everyone is presumed to do the major position of his thinking for himself, and of the indifference with which fields of investigation presumably worked out are so frequently regarded.

It was with a lively recollection of the brilliant manner in which Dr. Lodge revivified the whole subject and at a single stroke landed us in the midst of theoretical and practical considerations of the highest import, that we turned over the five hundred and odd pages of his book, hoping to find therein not a mere miscellaneous reprint of articles, lectures, letters, reports, and experiments, but a comprehensive and comprehensible treatise which should at once be a contribution to science and to literature. But few men are gifted at once with a facile pen and the scientific spirit, and it is therefore a cause for regret that when such a combination does exist, an opportunity should be lost of making science popular by rendering it palatable. To those, however, who desire to have Dr. Lodge's collected papers on lightning conductors in a handy form, the present compilation will no doubt be welcome.

The Gas, Water, and Electric Lighting Companies' Directory, Gas Works Statistics, Water Works Statistics. Edited by CHARLES W. HASTINGS. (London: Hazell, Watson, and Viney.)

This is a well-printed publication of moderate dimensions, about which it is easy to find one's way, considerations too frequently overlooked in books of reference. Section IX., which is devoted to electric light undertakings, is marred by several sins of commission and omission, of which we give a few specimens. Unfortunate Barnet, although it has long since "gone back to gas," is the first name that meets the eye, and the arc lights which at the present moment nightly illumine Fleet-street notwithstanding, the western district of the City is still returned as unallotted to any company. Again, the Deptford *district* is credited with 40,000 lights and the Grosvenor Gallery with none. On the other hand, while small fry like Larne and Carlow are duly recorded, there is no mention of Dublin. Cardiff is down as still being in the hands of the Brush Company, and the column in which is recorded the number of lamps supplied suffers in many instances from a retardation of phase of about a twelvemonth. The items of information given are indeed just those wanted by business men, but the Editor must not forget that electric lighting is an advancing industry, and that what was possibly correct in June, 1891, is not so in June, 1892.

The Phonograph and how to Construct it. By W. GILLET. (London: E. and F. N. Spon, 1892.)

This book is devoted to one of those examples of useless labour upon which so many amateurs, who have a knowledge

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of the use of tools and leisure for mechanical construction, waste their time and skill. It is a pity that the perseverance and ingenuity of such triflers cannot be "directed for the use and convenience of man," instead of being expended on toys of this kind. In making a "tinfoil phonograph" it is directed that the thread on the shaft should be cut with ordinary gas thread, by stocks and dies, for it is a point of honour with a certain class of amateurs to do all the work at home, whether proper tools are available or no. Out of 84 pages, less than eight are devoted to the construction of an electric motor to drive the phonograph. The wax cylinders, as described, take "nearly half-a-pound of wax" each.

GEARING.

BY E. TREMLETT CARTER.

(*Continued from page 588.*)

Worm Gear.

This is by far the best form of speed reduction gear for traction motor work, and even for another work it possesses merits which are not found in any other form. The first to apply it to electric traction was Mr. Reckenzaun, who has always found it a most efficient and reliable gear, and has used it in all his subsequent traction motor designs. Another authority, Mr. Holroyd Smith, after trying worm gear, has been loud in its praise, and has replaced every former gear with this particular kind. The writer has been led to make these remarks thus early in his account of worm gear in the hope

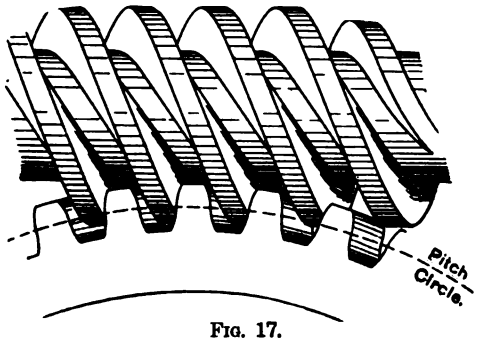

FIG. 17.

that the spice of the remarks may neutralise any prejudice against the poor worm which may have been lodged in the readers' minds from the too credulous perusal of theoretical textbooks, a prejudice which might otherwise have led them to pass on without reading his article. He hopes to show that the textbooks are misleading in this matter, and that the down-trodden worm is not as black as it is painted.

A glance at Fig. 17 will enable one to see the construction of single-thread worm gear. The gear consists in a driving spindle, on which a screw or thread is formed, and a spur wheel keyed to a driven spindle at right angles to the driving spindle. The teeth of the spur or worm wheel engage between the turns of the thread or worm, and as the latter turns on its axis the teeth are urged along in the direction of the worm axis, and the wheel is turned. In the single-thread gear, which is illustrated, each revolution of the worm spindle causes the engaged tooth to advance a distance equal to the space between the centres of two consecutive teeth, measured on a certain line called the pitch circle. This linear advance is called the pitch of the teeth, and it is evident that in single-thread worms it is equal to the pitch of the threads. The velocity ratio of single-thread gear is, therefore, equal to the number of teeth on the worm wheel. Thus, if there are 20 teeth on the worm wheel, a motor spindle turning at 600 revolutions per minute would cause the worm wheel to turn at 30 revolutions per minute. This high velocity ratio, however, could only be obtained at the sacrifice of a high efficiency, and where a lower ratio might be taken, if efficient working could thereby be secured, more than one thread is formed on the worm spindle. Double or treble-worm gear consists in two or three parallel threads placed on the spindle and gearing into the same worm wheel. In the former each thread misses one tooth, and in the latter it misses two teeth, as it coils round the spindle. It will be seen that in the double thread each revolution of the worm spindle causes the worm wheel to advance by the distance of two, and in treble-thread three, teeth of the worm wheel. In the latter the linear pitch of the thread is equal to three times, and in the former twice, the pitch of the teeth. The velocity ratio is then equal to the ratio of the number of teeth on the worm wheel to the number of threads on the worm.

In discussing this form of gear it will be very convenient to consider the threads unwrapped from the spindle and opened out to an inclined plane. In Fig. 18 a single turn of one thread has been thus unwrapped. A C is the circumference of the spindle at the pitch line, A B is the linear pitch of the thread, and B C is the length of one turn of the thread. The angle θ is the inclination of the axis of the worm to the plane of the thread; r is the radius of the spindle at the pitch line; t is the number of threads; p is the pitch of the *teeth*; and μ is the coefficient of friction between the thread and tooth engaged. The thread is driving the tooth, and is exerting an effort E in the direction shown. This force overcomes a resistance R, due to the driven tooth, and also balances a side-thrust T on the worm-wheel. This thrust and the resistance R combine to produce a normal thrust P on the face of the thread. The

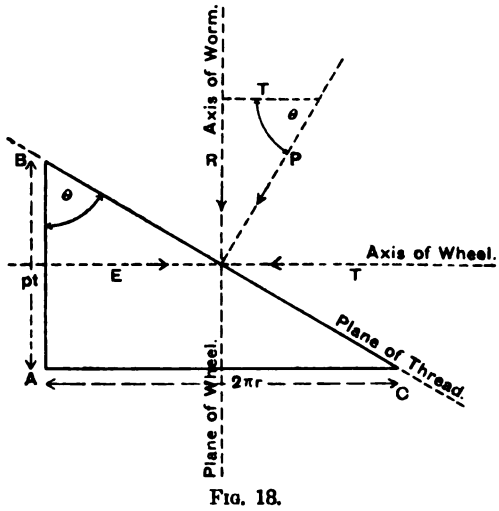

FIG. 18.

relationship between these forces is shown by the triangle of equilibrium. In one revolution of the worm spindle the effort E acts through the distance A C, so that the energy exerted is,

$$2 . \pi . r . E \quad . \quad . \quad \text{(energy exerted)}.$$

In the same time the force of resistance is overcome through the distance A B, so that the useful work done is

$$F . p . t \quad . \quad . \quad . \quad . \quad \text{(useful work)},$$

whence the efficiency is

$$\eta = \frac{F . p . t}{2 \pi r E}.$$

The energy wasted in overcoming friction is equal to the product of P into the coefficient of friction multiplied by the distance B C, and is also equal to the difference between the energy exerted and the useful work done. Whence

$$F . p . t = 2 \pi r . E - \mu . P . \left(\frac{2 \pi r}{\sin \theta}\right),$$

and

$$P = \frac{F}{\sin \theta};$$

whence

$$F . p . t = 2 \pi r E - \frac{2 \pi r . \mu . F}{\sin^2 \theta}.$$

Supplying the algebraic value of $\sin^2 \theta$,

$$F . p . t = 2 \pi r . E - \frac{\mu F \{(2 \pi r)^2 + (p t)^2\}}{2 \pi r}.$$

Dividing by the expression for the energy exerted we get

$$\eta = 1 - \frac{\mu F}{E} - \frac{\mu F}{E} . \left(\frac{p t}{2 \pi r}\right)^2.$$

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Whence, $$\eta = 1 - \mu\eta\left(\frac{2\pi r}{pt} + \frac{pt}{2\pi r}\right);$$

or, the efficiency of the gearing is

$$\eta = \frac{1}{1 + \mu\left(\frac{2\pi r}{pt} + \frac{pt}{2\pi r}\right)}.$$

Calling k the ratio of r to p, this becomes

$$\eta = \frac{1}{1 + \mu\left(\frac{2\pi k}{t} + \frac{t}{2\pi k}\right)};$$

or, supplying the trigonometrical values, we obtain another interesting, though not so convenient form,

$$\eta = \frac{1}{1 + \left(\frac{\mu}{\sin\theta \cdot \cos\theta}\right)}.$$

This last expression shows by inspection that the efficiency has a maximum value at a particular angle of thread, viz., 45deg. And the previous expression indicates that the efficiency of any particular design is independent of the actual dimensions of that design, except in so far as the size affects the value of the coefficient of friction. If this latter is constant, a small worm gear may be as efficient as a large one.

The conditions which secure a high efficiency are as follows:—The coefficient of friction should be small, the ratio k should be small, and the angle θ should be as near 45deg. as possible. It is not found to be practicable to make the ratio k less than 1·5, so that even with treble thread gear the angle is very much larger than the most efficient value. To obtain a pitch angle of 45deg. with this value of k it would be necessary to have 9 or 10 separate threads, a number which would be prohibitive except in the case of very large gear, and which has never been tried. The following table gives the relation between the values of k or t and θ or η, for worm gear having a coefficient of friction of 0·05. This value of μ has been taken as being an average figure where there is good lubrication, but it is probable that in the best instances of worm gear the friction has been much less than this. It will be seen how a low value for k and a high value for t are conducive to efficient running. Attention is particularly called to the high efficiencies in the multiple worm gear where k is small; figures which, derived as they are from pure theory, will help to settle the dispute about the inefficiency of worm gear. This table has been prepared especially for this series of Papers.

Table *giving the Efficiency and Pitch Angle (in degrees) for Single and Multiple Worm Gear* ($\mu = 0{\cdot}05$).

Number of threads.	Values of k.							
	1·5		2·0		2·5		3·0	
	θ	η	θ	η	θ	η	θ	η
1	84	66	85·5	61	86·4	56	87	50
2	78	80	81	76	82·5	70	84	66
3	72	85	76·5	82	79	79	81	76
4	67	88	72	86	76	82	78	80
5	62	90	68	87	72	85	75	83
6	57	90	65	88	69	87	72	85
7	54	91	61	89	66	88	70	87
8	50	91	58	90	63	89	67	88
9	46	92	55	91	60	90	65	89

It is sometimes desirable that the worm wheel should be able to drive the worm, and sometimes equally desirable that it should *not* be able to do so. In traction work, where an electromotor on the worm spindle drives a worm wheel on the car axle, it is necessary that when the current is switched off the momentum of the car should be able to drive the gear by the pressure of the teeth on the worm thread. For, if this provision were not made in designing the gear, the momentum of the car, being unable to drive the gear, would strip the teeth from the wheel. On the other hand, in cranes, hoists and elevators driven from an electromotor by worm gear, it is as necessary that the raised weight should *not* be able to turn the gear. For, if an elevator cage could drive the worm when the current was switched off, a serious element of danger would be introduced in the liability of the cage to fall when it was intended to be at rest. In such cases it is necessary that the gear should positively lock itself against reverse motion. By increasing the angle θ we may make the gear pass from a condition in which running back is impossible to one in which the wheel will drive the worm very easily. If θ is equal to or less than the limiting angle of friction for constrained motion, slipping cannot occur. This is the case when

$$\mu \geqq \cos\theta . \sin\theta.$$

Single thread gear of small pitch will, therefore, be used in cranes and hoists, and double or treble threads in gear for traction.

In order to eliminate the losses due to friction between the threads and teeth abundant lubrication is necessary. Mr. Reckenzaun and others have placed the entire gear in an oil bath, and the arrangement employed by Mr. Reckenzaun, who was the first to employ oil baths for electric traction work, is shown in Fig. 19. This consists in a sheet iron vessel completely enveloping the worm and wheel, through which the spindles pass by means of tightly fitting glands. The vessel is partly filled with oil, and the worm wheel carries this oil to

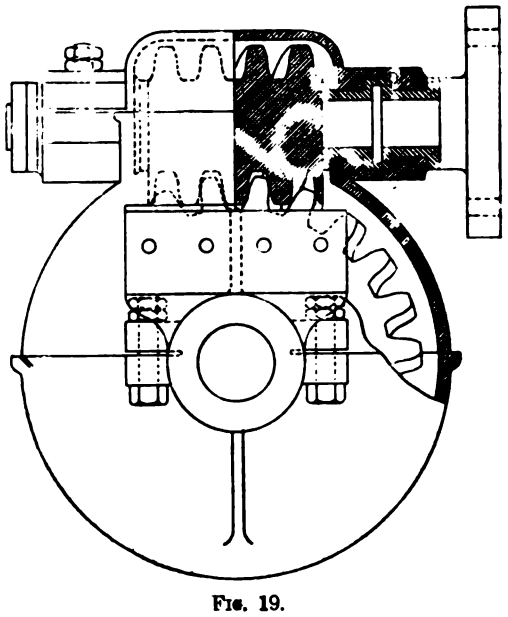

Fig. 19.

every moving part of the machinery. In addition to supplying the gear with almost perfect lubrication, this arrangement protects it from dust and mud. The worm shown in this figure has three threads, so that the losses due to friction are very small indeed.

In order to arrive at a better knowledge of the working powers of worm gear than was indicated by the usual theory, as well as to test the truth of the assertions that this form of gear was highly inefficient, Mr. Reckenzaun some years ago conducted a series of careful tests on a specially made set of worm gear. The worm was turned out of a solid cylinder of steel and highly polished. It consisted of three threads of 6in. diameter at the pitch line and 6in. pitch, gearing into a worm wheel fitted with phosphor bronze teeth of 2in. pitch. The wheel was 15¼in. in diameter at the pitch circle, and the width of each tooth was about 3½in. The velocity ratio of the gear was therefore eight. After every part had been carefully polished the gear was placed in an oil bath, and driven from an electromotor. The power supplied was measured by taking the watts supplied, and the useful power by means of Prony brakes on the spindles. The results are published in the French system of units, but the writer has reduced them to our usual system, and has also added some lines giving the total pressure and the pressure per inch width of the teeth. It will be observed that the higher efficiencies were obtained when the normal pressure between the tooth and the thread was low, *i.e.*,

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when the pressure did not squeeze the oil from between their surfaces. The second test is also interesting from the fact that there is an increase of efficiency notwithstanding the increase of pressure. The reason for this is undoubtedly to be found in the increased speed of the gear, which lapped up the oil more abundantly, and carried it between the surfaces in spite of the higher pressure.

Efficiency Tests of Multiple Worm Gear.

Number of Test.	I.	II.	III.	IV.
Revolutions per min. of worm wheel	38	84	96	112
Ft. lb. supplied per min.	37,600	84,960	72,828	56,743
Ft. lb. utilised per min.	32,500	76,111	66,758	54,151
Linear velocity of wheel in ft. per min.	152	336	384	448
Thrust on tooth in lb	248	250	189	126
Thrust per inch width of tooth	71	72	54	36
Normal pressure on threads	260	263	199	132
Normal thrust per inch width of contact surface	75	76	58	38
Efficiency	84·3	89·6	91·6	95·4

From the above analysis of the series of tests it would appear that the best results are obtainable with a working resistance not exceeding 36 lbs. per inch width of tooth, and with a high peripheral velocity of the wheel. The tests make it very clear that a high efficiency is a practical possibility, and even easily attainable. A further point of interest attaches to these tests, as they show how important in engineering are the choice and careful preparation of materials. The utmost care was exercised in selecting the working materials, steel and phosphor bronze, with a light lubricating oil, being taken on account of the very low coefficient of friction which they possess. And no less care was taken to produce a reliable finish in the surfaces of the working parts; the steel worm being accurately turned out of a solid piece and finely polished, and the morticed teeth being properly trimmed and polished as well. Comparing the results which this care has produced with the experiences of engineers who have used the common cast steel or iron threads gearing into cast iron and unpolished teeth, we may consider a single example. "A very able and experienced mechanical engineer told me," writes Professor Hele Shaw, "the result of an experiment he had made with a worm and cast iron worm wheel, for transmitting power, in combination with a nut and screw, in which the efficiency of the mechanism was *only 3 per cent.*" The marked contrast speaks for itself.

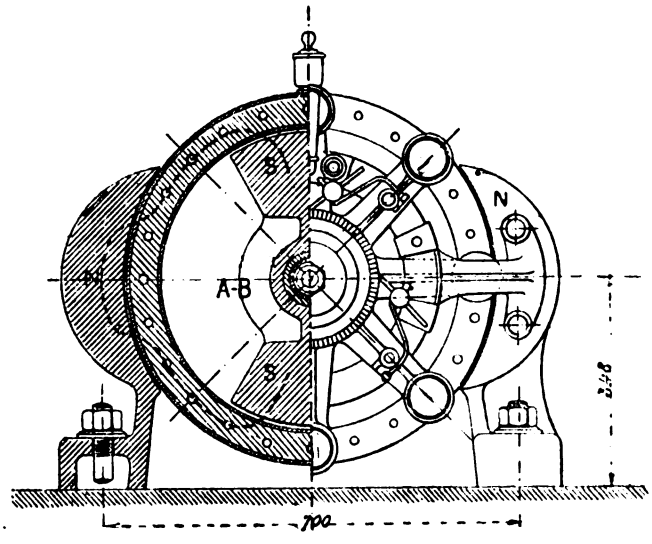
The worm gear employed by Mr. Reckenzaun on electric tramcars which he has designed differs in no important detail from the gear used in these tests, which has already been described. The running is found to be smooth and regular, the action on steep gradients certain, and the loss of power and depreciation low. Such gear will run for thousands of miles, or stand the daily wear and tear of twenty years' active work, before it is worn out. The reader is referred to a recent number of *The Electrician* (p. 63, May 20, 1892) for a very good diagram of the arrangement of worm gear on the motor trucks of the Bradford electric tramway, which will illustrate the manner in which worm gear is applied to traction work.

(To be continued.)

THE KŒCHLIN AND MARIOTTI DYNAMOS.

Dynamos having been constructed with external poles and with internal poles, the next step was evidently to bring out a machine combining both arrangements. There are several patents embodying this idea, amongst others one of Edison's, and last year the Société des Téléphones de Zürich put the Mariotti machine on the market, and the Ateliers de Constructions Mécaniques de Vevey showed the Kœchlin dynamo at an exhibition at Saint Etienne. The Esslingen Machine Works also showed a 1 H.P. motor of this type at the Frankfort Exhibition.

In the accompanying figure a Kœchlin dynamo is shown partly in section and partly in end elevation. The armature, which is of the ordinary Gramme pattern, is overhung to permit of the pole pieces embracing it externally as well as internally. The field is generated by a single coil. The machine has two pairs of poles at right angles to each other,



Kœchlin Alternate Pole Dynamo.

the N poles being outside and the S poles inside the armature, so that the lines of force are obliged to traverse the armature core. The frame is made in a single casting, extra soft steel being usually employed. The following are the data relating to the machine illustrated:—

Output at 550 revolutions (120 v × 100 a)	12,000 watts
Weight of copper on armature	18 kg.
" " " " field	72 kg.
Resistance (hot) of armature	0·86 ohms
" " " field coils	18·5 ohms
Current density in armature (3,225 per sq. inch)	5 amp. per sq. mm.
Ampere turns	8,970
Internal air-gap	10 mm.
External "	11·5 mm.
Total weight with pulley	1,100 kg.
Length of armature wire per volt	0·8 m.
Loss in watts per sq. decimetre of surface	6
Watts per kilogramme of armature wire	666
" " " total weight	11

A 6-pole 300 H.P. machine built on these lines will shortly be installed at Monthey (Valois) for transmission of power purposes.

The Mariotti machine is precisely similar to the Koechlin, with the exception of minor details.

M. A. Palaz sums up the pros and cons of this type of dynamo in *L'Electricien* somewhat as follows:—Low speed for a given voltage, and therefore peculiarly suitable for small waterfalls. Constant lead due to the extension which may in this type of dynamo be given to the pole-pieces without fear of magnetically short-circuiting the armature; good ventilation of the armature. On the other hand, the first cost of small machines of this type is excessive.

JAPANESE ELECTRICITY.

We have lately received the *Journal* of the Electrical Society, Tokyo, No. 46, Vol. IX., and the Calendar for Meiji, XXIV.—XXV., that is, for 1891-92, of the Imperial University of Japan. The latter is all in English, the former in Japanese, with the exception of a bit here and there, which is printed in English, perhaps in order that the ignorant foreigner (that is, the non-Japanese) may be properly appalled with the depth of knowledge displayed in this Tokyo electrical journal.

We reproduce (slightly reduced) the title-page as it appears in Japanese and English, and a celebrated Japanese scholar to whom we have submitted the book tells us that the title-page is

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電氣學會雜誌

第四拾六號 明治廿五年五月三十一日刊行

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(禁賣買)

No. 46. Vol. IX.

JOURNAL
OF THE
ELECTRICAL SOCIETY
TOKYO.
MAY, 1891

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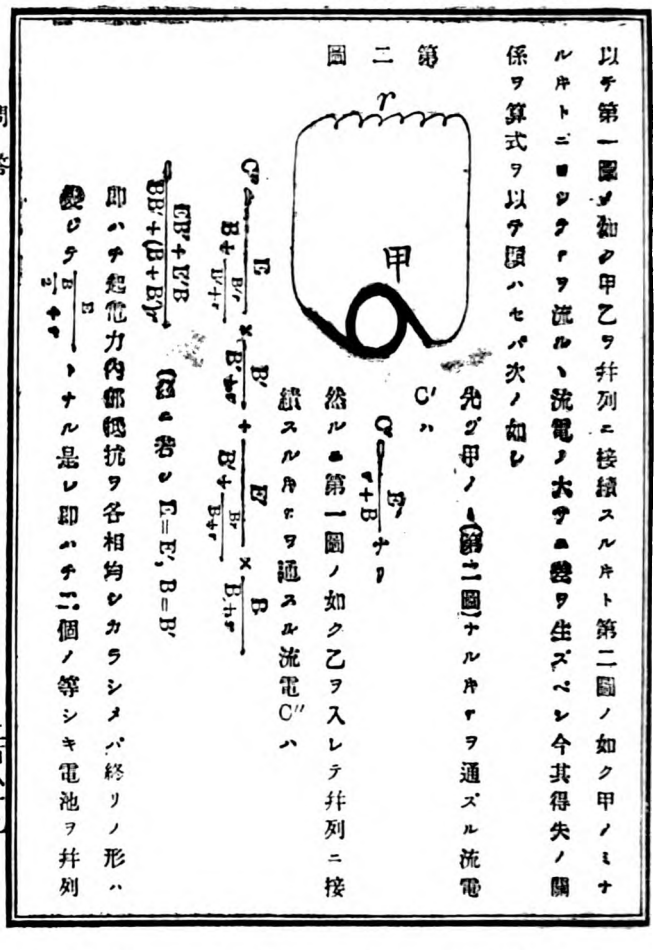
Sekibunsha. No 13 Yumicho. Kiobashi-ku, Tokyo

literally translated. We do not know, however, whether the first word in "Minuits of the Previous Meetings" is in the original Japanese untranslated—it is clearly not English. On the subject of the third communication, by Y. Touchiya, "Telephone Troubles, and How to Find Them," we feel that we could write volumes. We never yet met a Londoner who had experienced the slightest difficulty in finding telephone troubles, or who was seeking for help in his search. Nothing made us more touchier or more like the author of this communication, "Touchiya," than an attempt to use the telephone instrument which formerly hung up in our room in the west of London. Frequently have we unintentionally assisted in large sales of grey shirtings and pig iron between someone and someone else, who shouted so loudly, that all we could do was to assure our friend at the other end of the telephone wire—our telephone wire—that we would send a boy with a note.



To read a Japanese book you start at the right-hand top corner of what we should call the last page, then you proceed to read down each vertical column of the worm-like letters. Hence, a mathematical equation, which usually appears in English amongst these columns of Japanese characters, has to be printed standing on its end, as is seen in the sample page reproduced; and the Japanese scholar reads the equation end on without troubling to turn the page round. But this comes quite easy to a race of artists who, while they are drawing a horse, often place the picture with the animal standing on the end of its tail or on the tip of its nose. No wonder the Japanese nation is famed for its acrobatic and balancing feats.

Topsy-turvydom seems to be the characteristic of Japan. Not only do the people write and read backwards, but the carpenters saw and plane backwards; and, while in the early days of newspapers in that country manuscripts, proofs, and everything in connection with the Press could be sent post-free, to day the laws are such that the newspaper staff divides its time about equally between the editorial desk and prison. But in science and engineering the motto is forwards, not backwards; and those islands in the far East whose position,

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relatively to the Pacific and Eastern Asia, is exactly similar to the position of the islands constituting Great Britain relatively to the Atlantic and Western Europe, have so closely copied our own country that not only are there several electric lighting companies in Japan, but some of them have failed to pay any dividend.

In this *Journal* of the Electrical Society of Tokyo there is a contribution in English bristling with Fourier-Bessel functions, "Note on the Vibration of Telephone Diaphragm" (observe the absence of an article before "Telephone"), by Hantarō Nagaoka, who, we find, is the Assistant Professor of Physics in the University. The result, however, arrived at towards the conclusion of the article must be pretty obvious, even to a non-mathematical telephone maker, viz., that, in order to obtain good intonation, the end of the permanent magnet should be fixed opposite the middle of the telephone diaphragm, and not to one side. This application of elaborate mathematical equations to the elucidation of self-evident facts would qualify Mr. Nagaoka to hold a chair at a British University.

A study of the Calendar of the Imperial University of Japan, which occupies some 300 pages, is more interesting, and shows the wonderful strides that country has made in the last 20 years. The University consists of six distinct colleges, respectively of Law, Medicine, Engineering, Literature, Science, Agriculture, and a University Hall; and in the Colleges of Engineering and Science alone there are no less than 31 Professors, 14 Assistant Professors, and 8 Lecturers, the chief Professor of Electrical Engineering having been a Japanese student at the City and Guilds Central Institution a year or two ago, after having previously spent over 15 years studying electrical engineering at the former Imperial College of Engineering, Tokyo, and at the Cornell and other Universities in America.

At the starting of this Imperial College of Engineering in 1873 the English professors prepared a Calendar and programme of the courses. This the authorities decided should be translated into Japanese; but the Japanese language resembles the German, in that the nouns are made up of descriptive syllables, so the translators requested to be informed of the exact meaning of such words as electric potential, magnetic flux, &c. They were assured that if they became industrious pupils they would in a few years grasp the exact meanings of such words, and then they could build up Japanese equivalents. But that would not do at all; the Government had ordered the programme to be translated, and translated at once it must be. We do not know what exact ideas the Japanese edition of the College Calendar of 1874 conveyed to the natives; but we know that the Japanese language, possessing neither the letter l nor r, but only an intermediate sound, caused one of the subjects taught, as stated in the English edition of the Calendar, to become "Natural Phirosophy," suggesting that the professor of this science was of a hotter temper than we trust the Japanese students found him to be. P. D.

ELECTRO-METALLURGY.*

BY J. WILSON SWAN.

This is not the first time a lecture has been delivered here on electro-metallurgy. I find that so long ago as January, 1841, there was a lecture on the subject by Mr. Brand. At that time electro-metallurgy was very new and very small. It consisted solely of electro-plating and electrotyping. Electro-plating had already begun to be practised as a regular industry, but it was still a question whether the new kind of plating was good, and there were not a few silversmiths who would not offer electro-plate for sale because of its supposed inferiority to plate of the old style. That question has long been definitely settled by the fact that every week more than a ton of silver is deposited in the form of electro-plate. Electrotyping in 1841 was not so far advanced—it had not then been taken hold of by the artisan and manufacturer—it was still in the hands of the amateur. While the voltaic battery was the cheapest source of electric current, electro-metallurgy was necessarily restricted to artistic metal work, or to those applications where the fine quality of the electrotype cast outweighed the consideration of its cost, or where only a thin film of metal was required for the protection of a baser metal from the action of the air. Within this limited field the electro deposition of copper, of gold, of silver, of iron, and of nickel, has been carried on commercially with very great success and advantage for almost the whole period of the existence of the art. But beyond these bounds, set by the limitation of cost, it could not pass.

Now, all this is changed—since engineer and electrician have united their efforts to push to the utmost the practical effect of Faraday's great discovery, of the principle of generating electric currents by motive power. The outcome is the modern dynamo, with its result—cheap electricity. The same cause that has led to electric lighting, and to the electric transmission of power, has also led to a very great development of electro-metallurgic industry, and not only in the old direction but in new. It is no longer a matter of depositing ounces of pounds of metal, but of tons and thousands of tons. And is no longer with metal deposition merely that electro-metallurgy now deals, but also with the extraction of metals from their ores, and the fusion and welding of metals. Electro-metallurgy has, in fact, grown so large and many-branching, that it is impossible to treat it in a complete manner in a single hour.

One of the latest developments is electric welding. This, in one of its forms, that invented by Elihu Thompson, has recently been so thoroughly explained and demonstrated by Sir Frederick Bramwell, that it is not necessary for me to do more than mention it as belonging to the subject. There is also another species of electric welding—that of Dr. Benardos—in which the electric arc is used after the manner of a blow-pipe flame, to obtain the welding of such forms and thicknesses of iron, steel, and other metals, as would be difficult or impossible to weld in any other way; and not only is the electric blow-pipe used for welding, but also for the repair of defects in steel and iron castings, by the fusion of pieces of metal, of the same kind as the casting, into the faulty place, so as to make it completely sound. This new kind of electric welding, as improved by Mr. Howard, is now of sufficient importance to entitle it to the full occupation of an evening. I therefore propose to leave it for detailed description to some other lecturer, and content myself with calling your attention to the interesting collection of specimens on the table, and in the library (lent by Messrs. Lloyd and Lloyd), showing the results of this process.

Even with this curtailment, the extent of the field is still too great, and I must reduce it further by omitting a considerable section of that portion which relates to the extraction of metals from their ores, and, in this connection, only speak of the extraction of aluminium. But, in the first place, I am going to speak of the deposition of copper. One of the wonderful things about the electro-deposition of copper, and, in fact, any other metal deposited from a solution of its salt in water, is, that bright, hard, solid metal, such as we are accustomed to see produced by means of fusion, can, by the action of the electric current, be made to separate from a liquid which has no appearance of metal about it.

For the reproduction of fine works of art in metal, electrotype is unapproachable. The extreme minuteness with which every touch of graver or modelling-tool is copied by the deposited metal film, separates electrotype by a wide space from all other modes of casting. Even the Daguerreotype image is not too exquisitely fine for electrotype to copy it so perfectly that the picture is almost as vivid in the cast as in the original. It is this quality that has given to electrotype a *rôle* which no other process can fill, and, so far, its practical utility is not greatly dependent on the cost of the current. This applies to all those most beautiful things here and in the Library, lent by Messrs. Elkington. These could all have been produced commercially, even if there had been nothing better for the generation of the current than Smee's battery—a very good battery, by the way, for small operations in copper deposition. It gives a very low electromotive force, and that is a defect; but in copper deposition, the half-volt or so is generally sufficient to produce, automatically, the required current destiny. One of the uses of electrotype, not greatly affected by the cost of deposition, is that of the multiplication of printing surfaces. In these days of illustrated periodicals, electrotype has come more and more into use for making duplicate blocks from wood engravings, which would soon be worn out and useless if printed from direct. It is also employed to make casts from set-up type, to be used instead of ordinary stereotype casts, when long numbers of a book have to be printed; also as a means of copying engraved copper-plates. Here are examples of all these uses of the electrotype process. The electro-blocks are lent by Messrs. Richardson and Co., and the copper-plates by the Director-General of the Ordnance Survey Office, Southampton. The plates illustrate the method employed at Southampton in the map-printing department. The original plates are not printed from except to take proofs. The published maps are all printed from electrotypes. Here is an original plate—here the matrix or first electro, with, of course, all the lines raised which are sunk in the original. The second electro is, like the original, an intaglio. Here is a print from it, and here one from the original plate.

* Friday evening discourse delivered at the Royal Institution.

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Practically they are indistinguisable from each other, and bear eloquent testimony to the wonderful power of electrotype to transmit an exceedingly faithful copy of such a surface.

Nickel has, of late years, come into extensive use for what is termed nickel-plating, as applied to coating polished steel and brass with nickel. Nickel not only has the advantage over silver of cheapness, but also, in some circumstance, of greater resistance to the action of the air.

Another metal, usually deposited in the form of a coating, is iron. The electrolytic deposit of iron is peculiarly hard—so much so, that it is commonly but erroneously spoken of as *steel*-facing. The deposition of a film of iron upon engraved copper plates, as a means of preventing the wear incidental to their use in being printed from, has become almost universal. Valuable etchings, mezzotints, and photogravure plates are thus made to bear a thousand or more impressions without injury. By dissolving off the iron veil with weak acid, when the first signs of wear appear on the surface of the plate, and re-coating it with iron, an engraved copper plate is, for all practical purposes, everlasting. In this case, of course, the film of iron is extremely thin—one or two hundred-thousandths of an inch. But it is possible to produce most of the metals commonly used as coatings in a more massive form. Here, for example, is an iron rod half an inch in diameter, entirely formed by electrolytic deposition. I am indebted to Mr. Roberts-Austen for being able to show this.

These are all departments of electro-metallurgy which would have maintained a perfectly healthy industrial existence and growth without the dynamo; but now I come to speak of a branch of the subject—electrolytic copper refining—which, without that source of cheap electricity, could not have existed. This is the most extensive of all the applications of electro-chemistry, and is rendering valuable assistance to electrical engineering by the improvement it has led to in the conductivity of copper wire. One of the results of this is seen in the raising of the commercial standard of electrical conductivity Ten years ago contracts for copper wire for telegraphy stipulated for a minimum conductivity of 95 per cent. of Matthiessen's standard of pure copper. Now, chiefly owing to electrolytic refining, a conductivity of 100 per cent. is demanded by the buyer and conceded by the manufacturer.

To show the difference between the past and present state of things in relation to the commercial conductivity of copper, I am going to exhibit on the screen measurements of the resistance of six pieces of wire of equal length and equal cross section—they have been drawn through the same drawplate. Three of the pieces are new and three are old. The three new pieces are made from electrolytic copper, and are representative of the present state of things. The three old pieces are taken from three well-known old submarine telegraph cables, and they show how very bad the copper was when it was first employed for telegraphic purposes, and how great has been the improvement. I will take No. 1 wire as the standard of comparison. It is a piece of the wire about to be supplied to the Post Office Telegraph Department for trunk telephone lines. It will show the very high standard of conductivity that has been reached in the copper of commerce. I am indebted for it, and for two out of three of the old cable wires, to Mr. Preece. No. 2 wire is made from electrolytic copper, deposited in my own laboratory. No. 3 is also electrolytic copper, but such as is commercially produced in electrolytic copper refining; it has been supplied to me by Mr. Bolton, to whom I am also indebted for wire No. 6—a particularly interesting specimen; it is from the first Trans-Atlantic cable—the cable of 1858. No. 4 wire is from the Ostend cable of 1860, and No. 5 wire is from the old Duth cable. These wires are so arranged that I can send a small and constant current partly through any one of them and partly through a galvanometer. When this is done the result will be a deflection of the spot of light on the scale from the zero point to an extent corresponding to the resistance of the particular wire in the circuit. The worse the wire is, the greater will be the deflection. We will begin with the Post Office sample first. I connect the galvanometer terminals to wire No. 1; you see there is a deflection of ten degrees. I will now shift the contacts to wire No. 2—exactly the same length of wire is included—but now you see there is a deflection of slightly less than ten degrees, showing that this wire has a little lower resistance than No. 1. The difference is very small—it may be 2 per cent.—and 2 per cent. less if it would be required to conduct as well as the No. 1 wire. The next is No. 3. This is Mr. Bolton's wire, and shows a resistance almost equal to the last. Nos. 1, 2, and 3 are, therefore, nearly alike, and have a degree of conductivity almost as high as it can possibly be. Now we come to the three old wires. We will take No. 4 (the Ostend cable). There, you see, is a great difference. Instead of the spot of light being on the tenth degree, it was upon the eleventh. We will now try No. 5 (the Dutch cable). That drives the index to 17. Now I change to No. 6 (the old Atlantic cable), and we have a deflection of no less than 25deg. I suppose we may assume that this wire fairly represents the commercial conductivity of copper in 1858, for it is highly probable that for a work so important as the first Atlantic cable every care would be taken in the selection of the copper. The result of this experiment shows that the copper of that cable was extremely bad as a conductor—that, in fact, it is 150 per cent. worse than the best commercial copper of to-day. In other words, it shows that, in point of electrical conductivity, one ton of the copper of to-day will go as far as two and a-half tons of such copper as was used for the cable of '58. This change is largely due to electrolytic copper refining. To prepare the crude copper for the refining process it is cast into slabs. The cathodes are formed of thin plates of pure copper. Here are plates such as are used in electrolytic copper refining works. They are portions of actual cathodes and anodes, and represent the state of things at the commencement, and at the end, of the depositing operation—an operation that takes several weeks to complete, and effect the great change these plates show. In copper refining works an immense number of these plates, each having 6 to 10 square feet of superficial area, are operated upon together in a great number of large wooden vats containing sulphate of copper solution and a small proportion of sulphuric acid. Electric current from a dynamo, driven by a steam-engine or water-power, is conveyed by massive copper conductors to the vats, arranged in long lines of 50 or 100 or more in series. Thick copper bars connect adjoining vats, and provide a positive and negative support for the plates, which hang in the solution opposite each other, two or three inches apart. During the process the impure slabs dissolve, and at the same time pure copper is deposited from the solution upon the thin plates. The deposition and dissolving go on slowly, in some cases very slowly, for a slow action takes less power, and gives purer copper than a more rapid one. The usual rate is one to ten amperes per square foot of cathode surface. You will better realise what these rates of deposit mean, when I say that one ampere per square foot rate of deposition gives for each foot of cathode surface, nearly one ounce of copper in 24 hours, and a thickness of one-eight hundredth of an inch; and therefore the production of one ton of copper at that rate in 24 hours would require a cathode surface in the vats, in round numbers, of 36,000 square feet. At the higher rate of 10 amperes per square foot, which is used where coal is cheap, one-tenth of this area would be required.

The importance of the electrolytic copper refining industry, and the extent of the plant connected with it, may be inferred from the fact that, reckoning the united production of all the electrolytic copper works in the world, nearly one ton of copper is deposited every quarter of an hour. Very little power is required for copper deposition if the extent of the dissolving and depositing surfaces is large, relatively to the quantity of copper deposited in a given time. Some of the impurities ordinarily found in crude copper are valuable. Silver and gold are common impurities, and these and some other impurities do not enter into solution, but fall down as black mud, are recovered, and go to diminish the cost of the process or increase the profit; and even those impurities which enter into solution are, under ordinary condition, almost completely separated.

Electrolytic copper refining is both an economical and an effective process. The deposited copper is exceptionally pure. At one time it was supposed that it must necessarily be quite pure, but this is not the case; other metals can be deposited with the copper, but it is not difficult to realise in practice a close approximation to absolute purity in the deposited copper. Here is an example of the deposition of a mixed metal—brass, that is, copper and zinc deposited together, and there are in the Library a number of interesting specimens of mixed metal deposition. These deposits of brass and other alloys show that more than one metal can be deposited at the same time. The great enemy to conductivity in copper is arsenic, and the deposition of arsenic as well as copper is one of the things to be guarded against in electrolytic copper refining. Not only are the chemical characteristics of electrolytically refined copper generally good, but its mechanical properties are largely controllable. Usually electrolytic copper is melted down and cast into billets of the form required for rolling and wire-drawing. This treatment not only involves cost, but the copper is apt to imbibe impurity during fusion; though, if the process is carefully conducted, the deterioration is slight.

But it is evident that the re-melting of the deposited copper is a thing to be avoided if possible, and the question naturally arises, why, now that deposition costs so little, may not the beautiful principle which comes into play in electrotope, and which enables the most complicated forms to be faithfully copied be taken advantage of to give to plainer and heavier objects their ultimate form?

There are several reasons why this idea is not more frequently acted upon. One is that the process of electrolytic deposition is slow; another, that knowledge of the conditions necessary for obtaing a deposit having the required strength and other qualities is not very widespread. Moreover, in the electrolytic deposition of copper, and, indeed, of all metals, there is a strong tendency to

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roughness on the outside of the deposit, and to excrescent growths, the removal of which involve waste of labour and material. These tendencies can, to a very great extent, be counteracted by careful manipulation and the use of suitable solutions, and they can also be counteracted by mechanical means. This has been done by Mr. Elmore. He remedies the faults I have mentioned by causing a burnisher of agate (arranged after the manner of a tool in a screw-cutting lathe) to press upon and traverse a revolving cylindrical surface on which the deposit is taking place, and while it is immersed in the copper solution. The result is that it is kept smooth and bright to the end of the process. But the use of a burnisher is not the only means available for the production of a smooth deposit. It was observed in the early days of electro-plating how great a change was effected in the character of the metal deposited by the presence of a very small quantity of certain impurities. It was found, for example, that an exceedingly minute dose of bisulphide of carbon, if put into a bath from which the silver was being deposited, caused the deposit to change from dull to bright.

I have lately had experience of a similar kind with nickel and with copper. I was working with a hot solution of nickel, and up to a certain point the deposit had the usual dead-grey appearance. Suddenly, and without doing anything more than putting in a new cathode, I found the character of the deposit completely changed. Instead of the grey, tough, adherent deposit, there was produced a brittle, specular deposit, which scaled off in brilliantly shining flakes of metal. I sought for the cause of this extraordinary change, and traced it to the accidental introduction into the solution of a minute quantity of glue. By adding gelatine to a fresh nickel solution I obtained the same peculiar bright and brittle deposit that had resulted from the accident. I then made a similar addition to a solution of copper, and when I hit the right quantity—an exceedingly minute one—bright copper, instead of dull or crystalline, was deposited. Here are some specimens. These were deposited on a bright surface, and they are bright on both sides.

Not only is the copper made bright, under the conditions I have described, but, if the proportion of the gelatine be carried to the utmost that is consistent with the production of a bright deposit, it becomes exceedingly hard and brittle. Beyond this point the deposit is partly bright and partly dead, the arrangement of the patches of dead and bright being in some cases very peculiar, and suggestive of a strong conflict of opposing forces.

Before I leave the subject of copper deposition, I may mention that I have found the range of current density within which it is possible to obtain a deposit of reguline metal, far wider than is commonly supposed. The rate of deposition in copper-refining is usually very slow, and it is one of the drawbacks of the process, since slow deposition necessitates large plant. But rapid deposition necessitates a larger consumption of power, and larger cost on that account, and, therefore, there is a point beyond which it is not good economy to go, in the direction of more rapid deposition. Still there are cases where, if we had the power to deposit more rapidly, it might be found useful to exercise it. The subject of more rapid deposition is also interesting from a scientific point of view, I therefore mention an unusual result I have arrived at in this direction.

Taking as one extreme, the slow rate of deposit, of one ampere per square foot of cathode—a rate not infrequent in copper-refining, I have found that the limit in the other direction is not reached by a rate of deposit 1,000 times faster. I have produced, and I hope to be able to produce before you, a perfectly good deposit of copper, with a current density of 1,000 amperes per square foot of cathode.

This cell contains a solution of copper nitrate, with a small proportion of ammonium chloride. The plate on which I am going to produce a deposit of copper has an exposed surface of 21 square inches. Opposite, at a distance of one inch, is a plate of copper. When I close the circuit, a current of 140 amperes is passing through the solution. I continue this for just one minute. Now I wash it and remove the outer edge so as to detach the deposit, and as you see, I have a sheet of good copper—an electrotype. To have prodced a deposit of this thickness at the ordinary rate used in electrotyping operations would have occupied more than an hour.

In this experiment an extreme degree of rapidity of deposition has been shown. I do not intend to suggest that a rate of practical value. But it is at least interesting, as showing that the characteristic properties of copper are not less perfectly developed when the atoms of metal have been piled up one on the other at this extremely rapid rate than when there is slower aggregation. I think it probable that the rate of deposit intermediate between this rate and the usual one of about ten amperes per square foot may frequently be useful, for no doubt the slowness of the rate of deposit has often prevented electrotype from being made use of where, if the rate could have been increased ten times, it might have been used with advantage. Here are some thick plates, deposited at the rate of 100 amperes per square foot. They are as solid and as free from flaw as plates deposited ten time more slowly.

I said that electrolytic copper refining owed its existence to the discovery and improvement of the dynamo, and that other electro-metallurgic industries had originated from the same cause. One of these industries is the electrolytic production of aluminium. When Deville produced aluminium by the action of sodium on aluminium chloride, exaggerated expectations were entertained of the great part it was about to play in metallurgy. It was very soon found that aluminium had not all the virtues that its too sanguine frfends had claimed for it, but that it had a great many most valuable properties, and, given a certain degree of cheapness, a number of useful applications could be found for it. Some of these are suggested and shown by the various articles made of aluminium, kindly lent by the Metal Reduction Syndicate, and metallurgical research is rapidly extending our knowledge of its importance in connection with the improvement of steel castings, and the production of bronzes and other alloys of extraordinary strength. The cost of aluminium produced by Deville's process was too great to permit of its use on any large scale for these purpurposes. After Davy demonstrated, by the electrolytic extraction of potassium and sodium, the power of the electric current to break down the strong combination existing between the alkaline metals and oxygen, it seemed natural to expect that aluminium would also be reduced by the same means. But Davy did not succeed in producing any appreciable quantity of aluminium by the electrolytic method. Deville and Bunsen were more successful, but they did not possess the modern dynamo; that has made all the difference between the small experimental results they achieved and the industrial production of to-day, a production now so large that I suppose every day it amounts to at least one ton, and has resulted in a very great reduction of the price of the metal.

There are two electrolytic processes at work. One is the Hall process—employed at Pittsburg, and at Patricroft, Manchester—and now in experimental operation here. The other, the Herault process, worked at Neuhausen, is not greatly different from the Hall process—the shape of the furnace or crucible is different, and the composition of the bath yielding the aluminium may be different, but in all essentials these two processes are one and the same. They depend on the electrolysis of a fused bath, composed of cryolite, aluminium fluoride, fluorspar, and alumina. In the Hall process this mixture is contained in a carbon-lined iron crucible—the cathode in an electric circuit; and between which and the anode—a stick of carbon immersed in the fused bath—a difference of potential of 10 volts is maintained. In carrying out the process on a manufacturing scale, there are many of these sticks of carbon to each bath. Here, in our experimental furnace, there is only one.

The heat developed by the passing of so large a current as we are using (180 amperes) through an electrolyte of but a few inches area in cross section, is sufficient to melt and keep red hot the fluorides in which the alumina is dissolved. The electrolytic action results in the separation of aluminium from oxygen. The metal settles to the bottom of the pot, and is tapped or ladled out from time to time as it accumulates. The oxygen goes to the carbon cylinder, and burns it away at about the same rate as that at which aluminium is produced. It is only necessary to keep up the supply of alumina to enable the operation to be continued for a long time. I mean, of course, in addition to the keeping up of the current and the supply of carbon at the anode.

By far the greater part of the cost of aluminium obtained by electrolysis is the cost of motive power; 20 horse-power hours are expended to produce one pound of aluminium. Therefore it is essential for the cheap production of aluminium to have cheap motive power. There is one feature about the Neuhausen production of aluminium which is very striking, and that is the generation of the electric current by means of water power derived from a portion of the falls of the Rhine at Schaffhausen. The motive for making use of water power is economy. But, apart from that, it is interesting to see water replacing coal, not only in the production of power, but also in the production of the heat required in a smelting furnace.

Here is the Hall apparatus on a small scale. It is simply a carbon-lined iron crucible, and a thick stick of carbon. As already mentioned, the crucible is the cathode, the stick of carbon the anode. As the process takes time to get into full operation, it was commenced some hours ago, and at the rate at which it has been working we should by now have produced several ounces of aluminium. In beginning the process the charge has first to be melted. This is done by bringing the carbon stick into contact with the bottom of the crucible, so as to allow the current to pass from carbon to carbon to develop heat between the electrodes. The alumina compound, which, when melted, forms the bath, is added, in powder, little by little, and, when sufficient is melted, the carbon stick is raised out of contact with the bottom, and the electrolytic action then commences.

Here is the result of our experiment. It is not very large certainly, but it is quite enough for our purpose, which is to illustrate the principle of a newly-developed electro-metallurgical industry directly derived from discoveries made at the Royal Institution.

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GREENWOOD AND BATLEY'S ARC-LIGHT DYNAMO.

The Hochhausen dynamo appears at first sight to have been modified by Messrs. Greenwood and Batley, of Leeds, until it is hardly recognisable; but closer inspection of the illustration of this firm's new arc light machine shows that the rejection of the fantastic field magnets is the most noticeable feature, several of the original details, such as the air-insulated commutator, brush-holders, and main switch being retained. The mounting of the brushes on a large ring running on sheaves is still found on this machine, for it is part of the regulating system which is characteristic of the dynamo. The curious magnet yokes having been abandoned for a sensible arrangement, it has become necessary to modify the motor which is now placed in a subsidiary or shunted magnetic field between two projections from the pole pieces.

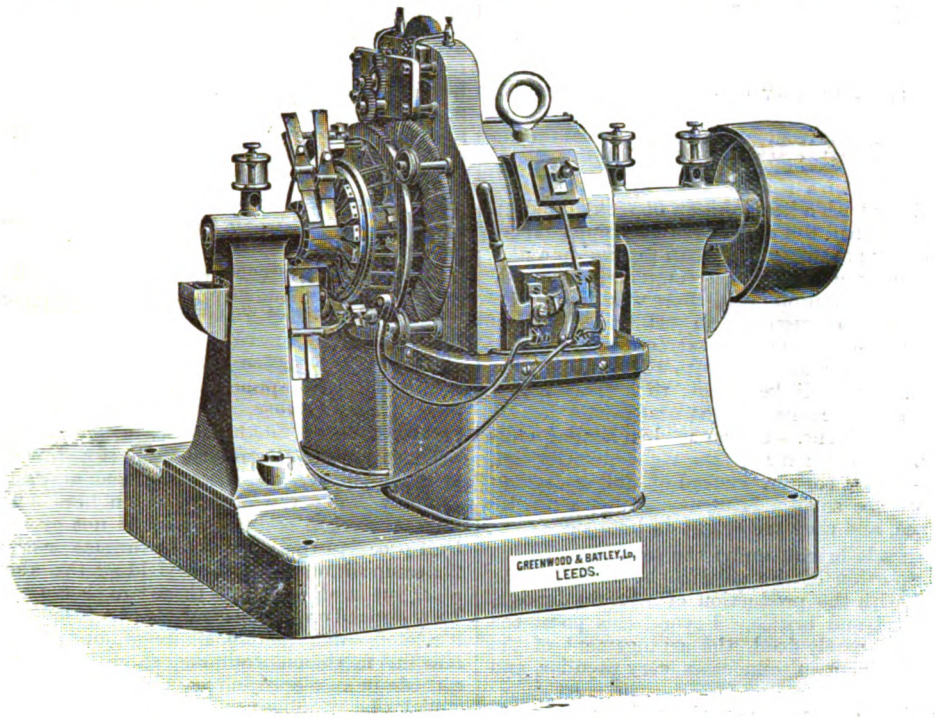

FIG. 1.—Greenwood and Batley's Arc Light Dynamo. General View.

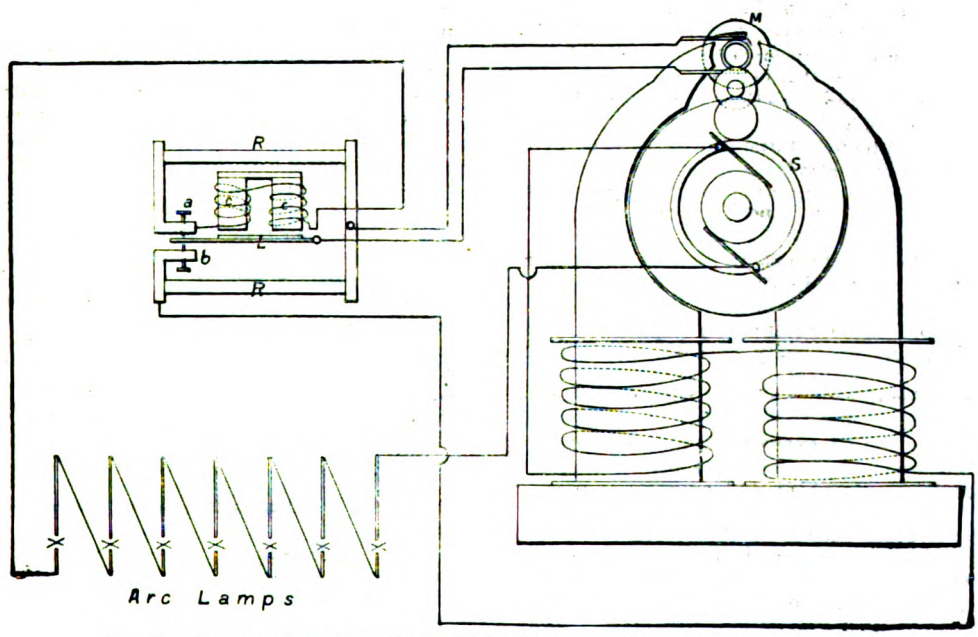

FIG. 2.—Greenwood and Batley's Arc Light Dynamo. Diagram of Regulating Gear

Fig. 1 shows the general arrangement of a 20-light dynamo with the regulating gear attached. In Fig. 2 the circuit is represented in diagrammatic form. A little flat ring armature M is provided with an ordinary commutator and a pair of brushes receiving a weak current through an automatic reversing switch. This switch consists of an electro-magnet energised by the main current, an armature L, which can make contact with either of the terminals *a* and *b*, and two resistances R, consisting of carbon rods about ½in. in diameter and some 6in. long. A small variation of the electromotive force in the main circuit will cause the armature L to make contact through *a* or *b*, as the case may be, and send a current through the armature M, in one direction or the other, and thus cause the latter to revolve forwards or backwards. By virtue of this rotation of M the circular rack S, supporting the brush-holders of the dynamo, will move slowly (it being driven through a small train of wheels geared to the spindle of M), and thus adjust the position of the dynamo brushes to suit the electromotive force demanded by any number of arc lamps arranged in series. The following tests have been made on a 20-light machine:—The machine was driven by an electric motor, the brake horse-power of which was easily ascertained, running at a constant speed of 750 revolutions per minute. The current was constantly at 10 amperes, and the average voltage measured 47 volts per lamp.

The regulator absorbs only 21 watts or about ¼ per cent. of the maximum load—quite a negligeable quantity. There is no sparking at the contact maker, and, when once adjusted, the

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automatic regulator will act promptly and without any further attention except an occasional dusting.

Tests of the "Leeds" Arc Dynamos.

Number of arc lamps.	Speed. Revs. per min.	Current. Amperes.	Brake H.P. absorbed.
5	750	10	6·31
6	750	10	6·98
8	750	10	7·81
12	750	10	10·65
16	750	10	13·1
20	750	10	15·2

COAST COMMUNICATION.

As was announced at the end of the last Parliamentary session, the Post Office, pending the publication of the Report of the Royal Commission on the telegraphic connection of lighthouses and lightships with the shore, had been directed to proceed with the carrying out of a scheme of telephonic communication between the chief coastguard stations and the nearest lifeboat stations. A sum of £20,000 was voted by Parliament for the work in the current financial year, and the following lines have, according to the *Post Office Magazine*, either already been or shortly will be run. All are telephonic circuits except where otherwise stated.

Coastguard Stations at Dungeness, Grand Redoubt, Station No. 1, Station No. 2, and New Romney.

Coastguard Stations at Ramsgate, Broadstairs, North Foreland, Kingsgate, Newgate, and Margate.

Coastguard Stations at Deal, Station No. 2, Sandwich, and Ramsgate.

Oxwich to Port Eynon Post Office and Rhossili.

Pembroke Dock Post Office to Angle Post Office and Coastguard Station.

An A B C line from Llantwit to Porthcawl and Swansea.

From Morthoe to Ilfracombe on the one side, and to Croyde on the other.

From Hartland Quay to Clovelly on the one side, and Bude on the other.

From the Lizard to Cadgwith on the one side, and to Mullion and Porthleven on the other.

From Swanage to Studland Bay on the one side, and to St. Alban's Head, Bottom, and Kimmeridge on the other, combined with an extension of an existing wire between St. Alban's Head and Corfe Castle to Poole, in order that the lifeboat there may be brought within call of the Coastguard Stations, as well as the lifeboats at Swanage and Kimmeridge.

From Beachy Head to Eastbourne on the one side, and to Newhaven and five intermediate Coastguard Stations on the other.

Extension of an existing A B C circuit between Kingsbridge and Prawle, to Salcombe on the one side, and to Rickham and Hall Sands on the other.

Telegraphic communication to Pennan, a village on an exposed part of the Scotch Coast, midway between the Lifeboat Stations at Fraserburgh and Banff.

A telegraph circuit from Hunstanton to Skegness.

Happisburgh to Palling, Thwart Lights, and Winterton.

Winterton to Caistor, Yarmouth, and Gorleston.

A telegraphic extension from Whiting Bay Post Office to Kilmorie Post Office.

Timoleague Post Office to Courtmacsherry Post Office and Coastguard Station.

The Coastguard Stations at Hunstanton, Thornham, and Brancaster Staith.

Croyde Coastguard Station to Appledore Post Office.

Appledore Post Office to the Coastguard Stations at Westward Ho! Peppercombe, and Clovelly.

The Coastguard Stations at New Clee, Cleethorpes, Tetney Lock, North Coates, and Donnanook.

Beal Post Office to Holy Island Coastguard Station and Post Office.

Beal Post Office to Goswick Coastguard Station.

Bamborough Post Office to Budle Coastguard Station.

Beadnell Coastguard Station to Seahouses Coastguard Station and Post Office.

Call bells in the Post Offices at Beal, Seahouses, Bamborough, Spittal, and Berwick.

Coastguard Stations at Winchelsea, Rye Harbour, Camber, Jury Gap, Galloways, and Dungeness.

Coastguard Stations at Dartmouth, Tor Cross, and Hall Sands.

Coastguard Stations at Salcombe, Sharp Tor, Bolt Head, Steeple Cove, Hope Cove, Bantham, and Challabrough.

Yealm Coastguard Station to Plymouth Post Office.

Coastguard Stations at Challabrough, Kingston, Mothecombe, Gunrow Head, and Yealm, and also the Chief Coastguard Officer's House at Yealm.

Coastguard Stations at Mevagissey, Gorran Haven, Dodman, Greeb, and Caerhays.

Coastguard Stations at Portscatho, Carne, Porthloe, and Caerhays.

Coastguard Stations at Cadgwith, Coverack, Porthoustock, Porthallow, and Gillan Creek.

Burry Port Coastguard Station, Burry Port Look-out, and Ferryside Post Office.

An arrangement for giving direct communication between Ferryside and Tenby Post Offices after official hours.

Post Office to Coastguard Station at Tenby.

Post Offices at Tenby, Saundersfoot, Amroth, Pendine, and Laugharne.

Coastguard Stations at Portscatho and Falmouth.

Telephone lines and submarine cables connecting the various Coastguard Stations in the Scilly Islands.

A telegraph extension to Fair Isle, Shetland.

THE INFLUENCE OF THE ELECTRIC LIGHT ON THE STRUCTURE OF HERBACEOUS PLANTS.*

BY GASTON BONNIER.

In a previous communication† the author showed that the structure of the leaves and young shoots of trees exposed continuously for a lengthy period to a globe-covered arc lamp, giving a constant light, underwent certain modifications. In the present communication the author describes some results relating to herbaceous plants cultivated under similar conditions and exposed also to the naked arc. Plants from which it was desired to cut off the rays were placed under a blackened screen. The plants were placed from 1·5 metre to 4 metres from the arc.

The author shows that powerful assimilation goes on in plants exposed to the electric light. The rate of assimilation is double that which obtains when plants are exposed to diffused sunlight, and is more than one quarter of that which obtains when plants are directly exposed to the strongest rays of the sun.

Like previous investigators, the author finds that some plants perish even when intermittently exposed to the electric light, especially if the arc is naked. A certain number of plants exposed continuously to the light of a globe-covered lamp, on the other hand, exhibited an exuberant development, the leaves being an intense green and the flowers deeply coloured. The greater number of such plants, however, appeared to suffer from this rapid development.

No notable anatomic modification was observed in the case of submerged aquatic plants, although their buds were greener when exposed to continuous light. Plants exposed direct to the naked arc light frequently had their tissues hypertrophied, or exhibited abnormal formations.

The author's conclusions are as follows:—(1) When the continuous glass-covered electric light causes considerable development in a herbaceous plant with an intense green colouration, the structure of the parts is at first very much differentiated; but if the electric light is powerful, and its application is prolonged for months without cessation or diminution, the newly-formed parts of such plants as are able to adapt themselves to this illumination exhibit remarkable structural modifications of the tissues, these being less differentiated although always rich in chlorophyll. (2) The naked electric light is detrimental by reason of its ultra-violet rays to the development of the tissues, even when the plants are more than 3 metres distant from the lamp.

BOOKS, &c., RECEIVED.

"Proceedings of the Royal Society." Vol. LI., No. 313. London: Harrison and Sons. (Price 3s. 6d.)

"The Engineering Telegraph Code." By A. H. Blackburn, M.I.M.E., and James Stevens, M.E., M.I.M.E. 9, Fenchurch-avenue, London, E.C. 750 pages. Crown 4to. 40s. net.

"Taschenbuch fur Monteure Elektrischer Beleuchtungsanlagen,' by S. F. V. Gaisberg. (München: R. Oldenbourg.)

"American Journal of Science," Vol. XLIV., No. 261. (New Haven, Conn., J. D. and E. S. Dana).

"Journal of the Iron and Steel Institute, 1892." (London: E. and F. N. Spon.)

* Abstract of a Paper read before the Académie des Sciences (*Comptes Rendus*, Vol. CXV., p. 475).

† See *The Electrician*, September 30th, p. 594.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 23, 1892.

Meeting of the Street Railway Association of New York.—The annual meeting of the Street Railway Association of the State of New York was held on Tuesday last at Saratoga, N.Y. This association is composed of the representatives of the leading street railways in the State, and although every effort has been made a number of times to secure something like a complete representation, the fact remains that only the larger companies are members of the association. At the meeting this week a smaller number than usual was represented, and, although five companies have joined the association during the year, the secretary called attention to the fact that the tendency of the times to consolidation had reduced the membership of the association to about two-thirds of what it formerly was. The two important features of the convention were the reading and discussion of Mr. McIntire's report on recent improvements in electric railways, and the organisation of what is to be called the Association of Dealers in Street Railway Supplies. Mr. McIntire's Paper dealt with the different features of the operation and construction of electric railways, and the discussion that followed it was chiefly taken up with the subject of track. The general opinion seemed to be that the faulty track construction, so often met with in street railways now in operation, was due to the fact that the companies had disregarded the experience gained by steam railroad engineers, and were not giving enough attention to the making of a solid joint between two consecutive rails. The organisation of an auxiliary branch of the association made up of the supply men, who, by the way, were more numerous at this convention than the members, is a new departure. This new association intends to assist the members of the parent association in attaining the objects for which the latter was organised, and to promote in every way possible the interests of street railway men throughout the State.

A Large Alternator.—The General Electric Company has taken in hand in a vigorous way the construction of large alternators for central station use. A plant is now in process of construction at the station of the Narragansett Electric Lighting Company, of Providence, R.I., in which the unit is a 375-kilowatt alternator, coupled direct to an Allis-Corliss compound engine, running at 90 revolutions per minute. The armature of the alternator replaces the flywheel of the engine, the field coils being carried upon a frame which rests upon the same base as the engine. The number of poles is in the neighbourhood of 80. It is expected that the machine will be ready for operation in three or four weeks, and will mark a distinct advance in the construction of electric lighting apparatus in this country. There is no mistaking the decided tendency towards larger units in stations where it is possible to make use of them. The General Electric Company is also building units for railway use which run as high as 500 or 600 kilowatts capacity.

The Niagara Falls Scheme.—The Cataract Construction Company, which up to this time has depended very largely upon foreign sources for advice in regard to electrical matters, has, it is understood, engaged the services of Prof. Henry A. Rowland, of Johns Hopkins University, as consulting electrical engineer. Prof. Rowland is now in New York City giving attention to some of the details of the work, and has been in consultation with some of the officials and engineers of the Company.

NEW YORK, *October* 1, 1892.

The Overhead Trolley System in New York.—The introduction of the trolley system into the upper section of New York, commonly known as the annexed district, was but the entering wedge. At a special session of the Board of Aldermen, held on Thursday, a franchise for the construction of trolley roads through the down town districts of New York were granted with such liberality that even the advocates of the trolley system have no reason to complain. About a month ago the large New York dailies took up the question of the dangers of the trolley system and treated the public for several weeks to column after column of reports of alleged accidents in different cities where the trolley had been introduced. Finally, however, their stock of information became exhausted, and for the last two or three weeks very little opposition has been evinced by the daily press. A number of papers have, indeed, printed articles more temperate in tone, and some even advocated the introduction of the trolley. Some of these articles evidently emanated from electric railway companies who were agitating to secure franchises in the down town sections of the city. Whatever their origin, they were soon followed by the action of the Aldermen on the applications made a short time ago, which had temporarily been referred to the Street Railway Committee. At the meeting on Thursday no less than nine franchises were granted, covering, perhaps, 12 to 15 miles of line in all, and permission was given in most cases to use the trolley system if desired. About 12 miles of the line is a surface road running directly under the structure of the elevated railway. This is, of course, one of the very best localities in the city for the use of the trolley, as overhead wires can here be attached directly to the high beams of the elevated railway. The vote with which these franchises were passed through the Board of Aldermen was 15 to 5, and, of course, the usual allegations of improper influence are rampant. The prime mover in the scheme is Mr. John D. Crimmins, well known as a big municipal contractor.

Test of a Stanley Transformer.—A recent test of a Stanley 17,500-watt transformer, made by Prof. Ryan, of Cornell University, shows excellent results. The method used by Prof. Ryan was similar to that described in his Paper on transformers before the American Institute of Electrical Engineers about two years ago, power dissipated through hysteresis, eddy currents, &c., being determined by the use of a contact maker, condenser and electrometer. The frequency was 132 ∽. The primary voltage being 1,000 and the secondary 50 volts, the drop in pressure from no load to full load was 2·3 per cent. The final results as to efficiency showed that the efficiency was 96·9 per cent.; at half load 97·1; at quarter load 96, and at one-eighth load 93; for one 16 c.p. lamp the efficiency as measured was about 24 per cent., the all-day efficiency was about 93·8 per cent., assuming that the transformer had a working output equivalent to 17,500 watts for five hours out of every 24.

The Siemens and Halske Electric Company of America.—The Siemens and Halske Electric Company of America are getting ready for business. A number of different types of machines will soon be placed upon the market. The Company will make a speciality, as was announced some time ago, of very large machines, the intention being to place generators and engines as high as 1,000 H.P. each upon the market immediately, or as soon as they can be constructed; at any rate, they will offer these for sale to whoever cares to purchase them. It was supposed by some that the Company would build machines of American design, but the latest information shows that the plans and designs for all their apparatus will be drawn direct from the large establishment in Germany, and the machinery constructed will conform to the designs that have already been tested in German establishments.

CORRESPONDENCE.

NAVAL SIGNALLING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Lieutenant Bacon, R.N., of H.M. torpedo ship "Vernon," Portsmouth, has thought fit to call in question, in your issue of the 30th ult., the value of my A B C system of electric signalling shortly referred to in your article of September 16th and in my letter of the 21st.

If I rightly understand it, the Baconian theory is (1) that I have "totally mistaken the signalling requirements of the Navy"; (2) it is very little importance to the Navy that signals may be read easily; (3) it is impossible to shortly state what the Navy *does* want in the way of signalling, since long and

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short messages have to be sent; (4) the Navy tries to get the best to suit the requirements which Lieut. Bacon finds it so difficult to define; (5) there are great disadvantages in the "flashing" and other systems in use; (6) that if presented to the Admiralty, and it passes the "first line of defence" (the Permanent Official), my invention will have a fair trial; (7) that, generally speaking, it is the exception for "shoregoing" people, or other than naval officers, to have any knowledge of life, or opportunities of noting "the conditions that surround life at sea"; (8) that because improved signalling is demanded by every craft great deliberation is necessary.

Lest it may appear to your readers that the writer is a "fearful example" of the "shoregoing" type, it may, perhaps, not be improper if I state that, as a native of a seaport town and the son of a naval man, my early associations were nautical. Entering the Greenwich Hospital School in 1858 (when Lieut. Bacon was a *quantité négligeable*), in the same year I made my first ocean passage and since then many others, which, in point of numbers and variety, will, I venture to think, compare favourably with the experiences of Lieut. Bacon during the 15 years he has been in the service, observing that, as the guest of naval captains and otherwise, I have witnessed nearly every operation, short of actual war, performed on board ships.

But the material point is that I claim to have invented a simple and ready system of signalling. Mr. Bacon says I have not. Again, is that system likely to meet with an immediate and fair trial in the Navy? To this question I must reply in the negative. Speaking with a painful experience of 16 years of Admiralty treatment in connection with my first invention, known as Kelway's Electric Log, I must conscientiously say that the official action has been scandalous. Similarly with other inventions I have since submitted.

The whole system of Governmental dealing with inventions is as unsatisfactory and unfair now as it was in 1872, when a British Association Committee reported at the Brighton meeting as follows:—

The Committee considered it fully established that the present methodical mode of dealing with inventions submitted to the different departments of Government was uncertain and unsatisfactory in itself, frequently unjust to inventors, and generally detrimental to the public administration. They considered it established to their satisfaction, that real injustice was frequently done to inventors, not only by neglect and procrastination in dealing with their claims, but also by the undue preference of other conflicting claims urged by officers of the different departments. Without entering into the merits of any case in point, it appeared beyond doubt that the practical judges of the inventions have been very often rival inventors within the departments. Your Committee feel that, if in every case officials appointed to investigate new inventions were required to affix their signatures to their reports, very beneficial results would follow, as the personal responsibility thus attaching to them would ensure their full attention, and deter them from rejecting hastily, or on insufficient grounds, any proposition or invention brought before them. The Committee consider their report would be incomplete if they did not call attention to an Act for preserving secrecy in the case of inventions connected with warfare. The Act is the 23rd Vic. cap. 13.

As night signalling at sea in the Mercantile Marine is practically non-existent owing to the difficulties attending the use of the "flashing" and other codes, for the present I consider it more profitable to direct my attention to commercial vessels, and to the use of the signals on land, for advertising and other purposes, where the "shoregoing" public can form its opinion as to whether there is "the slightest chance of its ultimate success."

Mr. Bacon will, I hope, excuse me if I remark that in ignoring the fact that my A B C system (in which the letters of the alphabet and numerals are, by the simple pressure on keys, presented to the observer) used with the naval private signal book provides absolute secrecy, he is doing me scanty justice. Reverting to the want of an accurate speed and distance measurer supplied by my electric log, and to other of my inventions, I may state that had fair treatment been accorded me, naval officers would not have so frequently laid themselves open to being placed in the category of "shoregoing" people as some have through the stranding of H.M.'s ships.

In proof that I am not alone in my opinion of naval management, permit me to quote Chief Engineer Isherwood, U.S. Navy (*Journal* of the American Society of Naval Engineers, August, 1892):—"Millions upon millions are now spent on vessels, which, for want of the necessary direct experimental information, have to be designed largely by rule of thumb and the imagination, because those who control the navies have neither the technical knowledge to properly direct, nor the judgment to sink pride of position and accept the guidance of those who have. The man who does not know, and does not know that he does not know, will not permit the man who does know, and knows that he knows, to direct his presumptuous action."—Yours, &c.,

C. E. KELWAY.

London, October 5, 1892.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sure that you have far more important demands on your valuable space than a continution of a discussion that, even at the early period of the third letter, has wandered from the main question, and become more a comparison of persons than facts. Still I must ask you to allow me to correct one or two points in Mr. Kelway's letter of the 5th inst.

In the first place, I have never thought fit to call into question the value of Mr. Kelway's A B C system, which I have never seen worked, and therefore it is impossible for me to form an accurate opinion of. But what I do call in question is the only advantage that Mr. Kelway advanced for it over our present system, viz., that "the mere fact of the signals being readable by uninitiated persons, as demonstrated to thousands at the above-named places, stamps the invention as one deserving the serious consideration and support of all interested in the important subject of night signalling." Now, Sir, this is the only advantage claimed by Mr. Kelway in his letter. Let him refer to it and see. I do not say that the system may not have many others besides, but this is the one he selected for his purpose, and it is this selection that led me to the opinion that "he had totally mistaken the signalling requirements of the Navy." I have done Mr. Kelway no injustice in saying that this particular advantage is not required, and pointing out that it may in cases be objectionable, The veriest tyro in signalling knows that, given a method of making distinctive signals, any *code* may be used; if a *code* be employed the advantage claimed is largely lost. The "Baconian Theory" is most useful, as by its light much may be read between the lines in the latter part of the letter. If any reader of this discussion cares to revert to my letter of the 30th ult., and compare the eight deductions from it, I think they will notice a distortion much to be regretted in any fair discussion. Nos. 1, 3, 4, 5, are legitimate, but 3 and 4 distorted. No. 2 is untrue, since the sentence has been altered from "*read by every casual observer*" to "*easily read*," two very different things. No. 6 should read "if presented to the Admiralty *and there is any chance of its ultimate success.*" The sneer about the permanent official is Mr. Kelway's. No. 7 is again unfair and should read, "It is the exception for shoregoing people to have any real knowledge of life or the conditions that surround life at sea." To insert "other than naval officers," when I was speaking generally of the sea, and not particularly of the Navy, is, in my opinion, to deliberately misquote, so as to be able to indulge in the luxury of a sneer. No. 8 should have conveyed the meaning that deliberation is required to make certain that new systems are real improvements, before the expense of introducing new systems in ships is undertaken.

Now, Sir, considering the bias of these quotations, the remainder of the letter is to me but the wail of the disappointed inventor. The Admiralty and naval officers are viewed through the lens of disappointment, and even our ships appear to be run ashore, not through tide or errors in judgment, but because they only use the harpoon and cherub log in conjunction, instead of trusting solely to Mr. Kelway's. One man is with him in this general mud throwing, for it is nothing more; and I would like to recommend part of his dictum to any reader, and ask him, with regard to the requirements of the Navy, which of the two, Mr. Kelway, or the average naval officer, is the man who does not know, and does not know that he does not know.

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I can only join issue with Chief Engineer Isherwood in lamenting that the man who does not know, and does not know that he does not know, will not permit the man who does know, and knows that he knows, to direct his presumptuous action. Who is who I leave to your readers.

Sir, I must apologise for the space I have occupied, but I shall not in the future further trespass on your columns on a subject made barren of interest by the fertility of the personality it has given rise to. I can only wish Mr. Kelway every success in his invention, and assure him of my conviction that if tried in the Navy its practical utility to us will be accurately assessed.—Yours, &c., R. H. Bacon, Lieut. R.N.

H.M.S. "Vernon," Portsmouth.

PRINTERS' MATHEMATICAL SYMBOLS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Prof. Silvanus Thompson invites suggestions for an easily-printed symbol to represent the exponential a^n. Would not $a \backslash n$ serve this purpose? In the example he gives, $A\epsilon^{-ax}$, there would be an ambiguity in writing it simply $A\epsilon \backslash -ax$, but it might be written indifferently, $A\epsilon \backslash (-ax)$, $A\epsilon \backslash -a.x$, or $A\epsilon \backslash -ax$; the last I should prefer if it can be easily set up by the printer, as most clearly showing what is intended.

I do not wish to criticise Prof. Thompson's own suggestion, but what your printer has set down, $A\,exp\,[-ax]$ can hardly be what he intended. The ϵ has disappeared altogether.—Yours, &c., Chas. T. Mitchell.

Lincoln's Inn, Oct. 13.

[This letter is referred to in our Notes.—Ed. *E.*]

ELECTRICAL RESISTANCE AND MAGNETIC PROPERTIES AT LOW TEMPERATURES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The experiments of Profs. Dewar and Fleming on electrical resistance at low temperatures have an indirect as well as a direct interest.

It has been observed in the case of iron and nickel that the temperature coefficients of resistance are much greater below the temperature at which the substances change from the magnetisable to the non-magnetisable condition than above that temperature. In the case of iron the coefficients are 0·019 and 0·007. If any such change occurred in the temperature coefficient, of copper for example, at a temperature sensibly above −197°C., Profs. Dewar and Fleming could have detected it. We may therefore infer, with considerable probability, that copper and platinum are not magnetisable at any temperature much above −197°C., and that gold, silver, aluminium and tin are not magnetisable at any temperature much above −182°C. The inference is important, as Faraday and others since his time have thought it probable that non-magnetisable metals might become magnetisable at a sufficiently low temperature.

It would be interesting to know the resistances of an alloy of iron and 12 per cent. of manganese at very low temperatures. If this material behaves like nickel-steel we should find that after cooling it would be magnetisable not only at the low temperature but at higher temperatures; also, that after cooling, the resistance at any temperature below a certain temperature would be less than the resistance at the same temperature before cooling. I have found that this material remains non-magnetisable at a temperature of about −100°C. Below that I have not the means of cooling.—Yours, &c.,

London, October 13, 1892. J. Hopkinson.

TRADE NOTES AND NOTICES.

Tenders Invited.—The Corporation of Wolverhampton invite tenders for constructing works for the supply of electricity to the central portion of the borough. Specifications and plans of the area to be lighted will be forwarded on receipt of £2. 2s., which is returnable if a *bonâ fide* tender is sent in. Tenders must reach Mr. Horatio Brevitt, town clerk, by 5 p.m. on Tuesday, November 15th. Further particulars appear in our advertisement columns.

Tenders Invited.—The Corporation of Southport invite tenders for the supply and erection of an electric generating plant at the central station, Crowlands, and for cables for the mains. Tenders can be sent in for the whole or for part of the various sections, which are set out in our advertisement columns. Specifications can be obtained of Mr. J. Davies Williams, town clerk, Southport, and tenders must be delivered not later than November 14th.

——— The Directors of the Belfast Central Hotel Company (Limited) invite tenders for the supply and erection of an electric light installation in their hotel premises, Royal-avenue, Belfast. The installation is to consist of two dynamos and from 500 to 700 incandescent lamps, and to be with or without additional arcs. Some particulars are given in our advertisement columns, and all further information and copies of specification can be obtained from the Directors. Plans can be inspected at the offices of Mr. Samuel Stevenson, 83, Royal-avenue, Belfast, and tenders must be sent in by the 28th inst.

——— The Dundee Gas Commissioners are prepared to receive tenders for the supply of a switchboard, instruments, &c., for their central lighting station. Tenders by the 22nd inst.

——— The Sutton Local Board invite tenders for lamps for the public lighting of their district by gas or other illuminant for one year. Tenders to be in by the 19th inst.

Tenders Accepted.—Messrs. Hammond and Co. have secured the contract for the erection of the new central electric lighting station for the Blackpool Corporation, which, in addition to working the electric tramway, is to provide current for lighting a portion of the borough.

——— The Portsmouth Urban Sanitary Authority have accepted the tender of Mr. T. W. Quick, of Southsea, for the erection of an electric lighting station in the Gunwharf-road, Portsmouth, the amount being £8,400.

Accumulator Traction.—The Electrical Power Storage Company (Limited) call our attention to the following circular letter which they are now issuing to the chief tramway companies in Great Britain, and which they consider is the best possible answer to the criticism that has lately been made on the expense for up-keep of batteries and electrical gear of tramcars:—

"We beg to call your attention to the fact that we are now prepared to negotiate for the working and maintenance of approved tram lines equipped with self-contained or storage electric cars. The terms under which such working and maintenance can be contracted for necessarily vary with local conditions, but the maximum charge would be 66 per cent. of the gross traffic receipts. You will readily note that such an undertaking should and does constitute the most effectual guarantee of perfection of service, and we shall be pleased to discuss the matter further with you at any time."

In reply to our inquiries for further information on the subject, we have received the following letter:—

TO THE EDITOR OF "THE ELECTRICIAN."

Dear Sir: I am obliged by your favour of the 10th. I quite agree that the up-keep of batteries does depend largely on the treatment by the drivers. Our maintenance of working propositions cover the supply of drivers, conductors, engineering staff and supervision, coals, repairs of steam engines and dynamos, repairs of machinery on cars, and maintenance of the batteries in satisfactory working order. It does not include the capital expenditure on the first supply of batteries; that is to say, we do not undertake to find capital for any tramway company, but merely to ensure that a proper profit is paid on the traffic, and if 34 per cent. of the gross receipts is not sufficient to maintain the permanent way, and the general secretarial office expenses of a tramway company, we do not consider that the tramway is worth our attention.

Further, we would not undertake the maintenance and working of any line where there were less than ten cars in constant running.

Trusting these particulars constitute a satisfactory answer to your query, we remain, yours faithfully,

The Electrical Power Storage Company (Limited),
Frank King, Manager.

Maquay Syndicate (Limited).—A resolution was passed and confirmed at meetings held on August 27th and September 27th respectively, that the Syndicate be voluntarily wound up, and that Mr. Thomas Rawlins, 45, King William-street, E.C., be the liquidator.

Messrs. Cox, Robinson and Co.—Mr. Arthur Thraves, accountant, of Liverpool, has been appointed trustee in the bankruptcy of this firm.

Electric Date and Time Stamp Company (Limited).—At meetings held on September 6th and October 4th a resolution was passed and confirmed that the Company be voluntarily wound up, and that Mr. J. M. Henderson, 2, Moorgate-street-buildings, E.C., be the liquidator.

Compagnie Parisienne de l'Air Comprimé.—Baron de Pefiel has been appointed Managing Director of this Company *vice* M. Victor Popp.

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REMOVAL NOTICE.—Mr. F. A. Butler, mica and talc merchant, notifies us of his change of address from St. George's-road, Peckham, S.E., to Grosvenor Park-road, Hoe-street, Walthamstow, E.

MESSRS. MATHER AND PLATT (LIMITED).—This firm have just completed the lighting of the Vaudeville Theatre, Strand, by the electric light, the installation consisting of 390 16-c.p. and 10 100-c.p. incandescent lamps. The whole of the contract, including fittings, &c., has been completed in twelve days.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).—We have received from this Company a new edition of their price list of electric light wires and cables. The list has been rearranged and divided into two sections, one being devoted to vulcanised and the other to unvulcanised wires. We notice that a column has been added giving the thickness of dielectric employed, an important matter too often omitted from lists of this kind. The weights per mile are less than in last year's list. For instance, taking 7/16 wire we find a dielectric thickness of 0·056", a weight of 790lb. per mile, with an insulation of 300 megohms in Class J, as against 852lb. last year, the outside diameter remaining 0·415 as before. In class K, as is well known, an insulation of 600 megohms is attained with the same dielectric thickness and a weight of 793lb.; while in the higher class L of 5,000 megohm insulation, the same sized wire has a dielectric thickness of 0·076, and weighs 865lb. The list of concentric cables has also undergone revision. The lead-covered cables are not given in a separate part of the list, but each lead-covered class is placed alongside the corresponding braided quality. We do not find J, K, and L, therefore, on the same page; but M, being J covered with lead, comes next to J, and N next to K. This is hardly an improvement, but the additional columns would not permit J, K, and L to be placed as before on one page.

MESSRS. B. VERITY AND SONS.—As evidence of the brisk competition now going on in the electrical and allied trades nothing is more noticeable than the special attention being paid by large supply firms to the preparation and printing of their trade catalogues, and no more complete specimen of this class of publication has recently appeared than that just issued by Messrs. Verity and Sons. This large folio book of 112 pages is crowded with illustrations of boilers, engines, pumps, turbines, dynamos, mining and milling machinery, launches, accumulators, accumulator sundries, transformers, arc and incandescent lamps, measuring instruments, switches and switchboards, safety devices, wires and cables, and all kinds of electrical and engineering sundries and accessories, including a very complete selection of electro-medical apparatus. In fact nothing is wanting as an aid in the selection of a complete plant, either for lighting or power.

THE FROUD JUBILEE TESTIMONIAL.—On Saturday last, at Cloot's Restaurant, Victoria-street, S.W., a presentation was made, consisting of a silver centre-piece for flowers and fruit, a very easy chair, and a beautiful illuminated address, to Mr. J. W. Froud to commemorate the jubilee of his entrance into the works of the well-known firm of Messrs. Benham and Froud (Limited), of Chandos-street. Many of the firm's former *employés* joined with those at present employed in forming a gathering which filled a spacious saloon to its utmost capacity. Mr. Laws, one of the directors of Benham and Froud (Limited) and honorary secretary to the Jubilee Testimonial Fund, having given a brief description of the origin of the committee's proceedings, Mr. Herbert Benham, in requesting Mr. Froud's acceptance of the gifts, spoke in high terms of that gentleman's connection with the extensive business carried on at Chandos-street. Mr. Froud, with much feeling, accepted the presentation and suitably replied, after which a musical evening followed, terminating with a vote of thanks to the hon. secretary and committee.

MESSRS. EASTON AND ANDERSON.—This firm are installing the electric light at the extensive flour mills of Mr. Seth Taylor, Lambeth, London, S.E.

MESSRS. GILBERT AND CO.—This firm have secured the contract for lighting the extensive buildings occupied by Mr. W. Straker at Ludgate-hill, E.C.

MR. WALTER LEAKE.—This gentleman has in preparation plans and specifications for lighting the Gresham Hotel, Sackville-street, and Messrs. Todd, Burns and Co.'s large drapery premises in Mary-street, Dublin.

THE DAIRY SHOW.—The annual exhibition of dairy produce and accessories is, as usual, a very successful one, the only drawback to the general convenience is the absence of the electric light, the excessive heat in the galleries rendering the promenade particularly disagreeable. Only spasmodic attempts at lighting by electricity are again noticeable, notwithstanding that the report had gained credence that an extensive installation of the electric light was some time ago imminent.

ASTON.—New public baths on an extensive scale have just been completed and opened at Aston, the buildings being lighted throughout by electricity. A novelty is introduced in the first-class swimming bath in the form of two powerful side lights with reflectors fixed three feet below the water line.

BATH.—With the commencement of the winter season the Bath Electric Light Company begins an all-day in addition to an all-night service, and have commenced charging by meter instead of by contract, as formerly.

BIRR.—The subject of the electric lighting of this town came under discussion at a recent meeting of the Local Authority; but the elections being imminent it was decided to defer taking any action in the matter until the new Board had been elected.

BOWNESS.—At the last meeting of the Local Board an agreement between the Board and Messrs. R. H. Fell and Son relating to the lighting of the streets was approved, an amendent that the Board make an application for a Provisional Order failing to find a seconder.

BRADFORD.—The Markets and Fairs Committee of the Town Council, having had under consideration three tenders for the fitting up of Kirkgate Market with the electric light, decided to recommend the acceptance of the tender of Messrs. Andrews and Preece, for supplying and fixing the necessary fittings, for the sum of £1,400, which recommendation has been adopted by the Town Council.

BRIGHTON.—At the last meeting of the Town Council the report of the Lighting Committee on September 19th, and recommending the laying of a distributing main from the north gate of the pavilion to the bottom of St. James-street, at an estimated cost of £350, came up for confirmation, and was duly agreed to.

BRISTOL.—The Bristol papers announce the gradual extension of the electric light beyond the boundary originally intended to be covered, the light having been received with much favour by the tradespeople in the adjacent districts. The Electrical Committee of the Corporation have been asked to make arrangements for a considerable extension.

CHELMSFORD.—The order of the Board of Trade directs that the wires used for the electric lighting in High-street and Tindall-street, Chelmsford, should be placed underground. The work has been commenced.

EALING.—At a Local Board meeting last week complaint was freely expressed at the increase in the price of gas recently decided upon by the Brentford Gas Company, and Mr. St. John moved that a committee be formed to consider the question of introducing the electric light. The motion was carried.

EAST MOLESEY (SURREY).—A fresh proposal for lighting this district by electricity has been submitted to the Local Authority, and has been referred to the General Purposes Committee for consideration.

EXETER.—Several Nonconformist places of worship in Exeter and the district have adopted the use of the electric light, the most recent being the large United Methodist Free Church.

HAMMERSMITH.—The Electric Lighting Committee of the Hammersmith Vestry have presented their report fixing the compulsory area for lighting under the Provisional Order. A noticeable feature of the meeting was the anxiety expressed by several of the members of the vestry that the electric light might be generally obtainable.

HAWICK.—The Town Council have under consideration a scheme for lighting Hawick with electricity, at a cost of £820. The scheme, which was prepared by Messrs. Mavor and Coulson, has been remitted to a committee to consider and report.

LLANDUDNO.—It is stated that applications are to be made for the laying down of an electric tramway along the beach at Llandudno.

MULLINGAR.—At the last meeting of the Town Commissioners it was decided to communicate with the Electrical Engineering Company of Ireland as to the probable cost of lighting the town of Mullingar by electricity.

RAVENSTHORPE.—A deputation of the Ratepayers' Association of this town has waited upon the Local Board with a resolution passed at their last meeting, urging the desirability of promoting the introduction of the electric light, and calling the attention of the Local Board to the heavy price paid for gas in the district. In reply to the deputation, the Chairman of the Board stated that the matter had been before them for the past 18 months, but they had thought it best to wait until the subject of electric lighting had developed.

SUTTON (SURREY).—At the last meeting of the Local Board the clerk reported that the Electric Light Order, giving the Board the monopoly of the electric light in Sutton, had received the sanction of Parliament, and the Board was now in a position to proceed with the matter.

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TOXTETH PARK.—At a Local Board meeting on Tuesday the recommendation of a special committee on electric lighting, that Mr. G. P. McMuldrow be appointed as electrical inspector at a salary of fifty guineas per annum, was confirmed, and it was announced that arrangements were being made with the Liverpool Electric Supply Company for lighting a portion of the township at a uniform rate of 7½d. per unit. The clerk was authorised to purchase certain electrical apparatus and lamp columns.

WINDSOR.—The Eton Electric Light Company (Limited) have served the usual statutory notice upon the Windsor Sanitary Authority of their intention to proceed with the opening of the streets in the borough for the purpose of laying the necessary cables for supplying the electric light. We understand the whole of the shares in the Company have been allotted.

WOLVERHAMPTON.—The Town Council had under consideration at their last meeting the Lighting Committee's report dealing with the suggested adoption of the electric light for the town. As will be seen elsewhere, the Town Council are advertising for tenders for the construction of the necessary works, an eligible site having been obtained. The report proposes that the Lighting Committee shall be a standing committee of the Town Council and that, if necessary, corporation stock shall be issued for the purpose of carrying into effect the Electric Lighting Order of 1890. The report has practically been agreed to.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

September 21, 1892.

16,903. H. H. LAKE. London. Improvements in, and relating to, electric accumulators. (F. C. Jenkins, Germany.)

16,904. J. HOPWOOD. London. An automatic switch for electric and other light applicable to a door.

16,906. R. R. HARPER. London. Improvements connected with audible telegraphs.

September 22, 1892.

16,919. J. SWINBURNE. Middlesex. Improvements in and connected with dynamo-electric machinery, alternating current motors, transformers, manufacture of ozone and oxide of nitrogen, recovery of tin from scrap, electro-plating with aluminium.

16,934. W. H. THOMPSON and R. THOMPSON. London. Improvements in volt-meters or electrical indicators.

16,948. E. DE PASS. London. A mode of and means for enabling boats to be propelled on navigable ways by electric energy. (E. Geisenberger, A. Sellier, and E. Guillemin, France.)

16,964. S. PITT. London. Insulating electrical conductors. (E. C. Davidson, United States.)

September 23, 1892.

16,980. J. J. ROBINS. Birmingham. Improvements in connections for electrical accumulators and other similar purposes.

16,997. T. G. USHER, R. USHER, and R. C. USHER. London. Improvements in electric bells.

17,004. F. D'A. GOOLD. London. Improvements in electric arc lamps.

17,022. G. WILKINSON. London. Improvements in, and relating to, the distribution of electrical energy.

September 24, 1892.

17,091. R. E. B. CROMPTON and H. J. DOWSING. London. Improvements in insulating and supporting electric wires intended to act as resistances.

17,092. R. E. B. CROMPTON and H. J. DOWSING. London. Improvements in insulating and supporting electric wires intended to act as resistances.

17,093. W. E. AYRTON and T. MATHER. London. Improvements in electrostatic measuring instruments.

17,099. H. T. BARRETT. London. An improvement in carbon electrodes.

September 26, 1892.

17,151. A. P. LUNDBERG. London. Improved "wall," "table," or floor connection for portable electric lamps.

17,160. J. E. KINGSBURY. London. Improvements in telephone switchboard apparatus. (The Western Electric Company, United States.)

17,169. C. KELLNER. London. Improvements in, or relating to, the electrolytical decomposition of metallic salts and in apparatus therefor.

September 27, 1892.

17,205. W. ALDRED. Sheffield. Continuous electric current machines and motors.

17,207. T. JOHNSTONE. Bradford. An improved ear piece for telephones.

17,209. R. H. BEST. Improvements in the slides of electric sliding pendants.

17,222. W. P. THOMPSON. Liverpool. Improvements in, or relating to, electric metal working or welding. (C. L. Coffin, United States.)

17,223. W. P. THOMPSON. Liverpool. Improvements in, or relating to, welding or working metals electrically. (C. L. Coffin, United States.)

17,224. W. P. THOMPSON. Liverpool. Improvements in apparatus for electrically heating or working metal. (C. L. Coffin, United States.)

17,225. W. P. THOMPSON. Liverpool. Improvements in the method of, and apparatus for, electrically welding metals. (C. L. Coffin, United States.)

17,226. W. P. THOMPSON. Liverpool. Improvements in the method of and apparatus for, welding or heating metals electrically. (C. L. Coffin, United States.)

17,227. W. P. THOMPSON. Liverpool. Improvements in, or relating to, electrically welding or heating metals. (C. L. Coffin, United States.)

17,242. P. A. NEWTON. London. Improvements in electro-medical appliances. (S. Hetherington-Carruthers, New South Wales.)

17,244. C. CASALONGA. London. Improvements in, or relating to, the supply of electricity to electrically propelled and controlled aerial machines.

17,246. T. J. D. RAWLINS. London. Improvements in, or connected with, electric primary batteries.

September 28, 1892.

17,287. J. HAMER. Halifax. A new or improved shield or cover for electric gas lighting purposes.

17,299. E. S. D'ODIARDI and E. S. D'ODIARDI. London. Apparatus for the inhalation of metals or minerals vapourised by means of electricity for medical, antiseptic, or other purposes.

17,304. T. AHEARN. Canada. Improvements in electric heaters.

17,321. T. AHEARN. Canada. Improvement in electric water heaters.

17,348. R. J. CROWLEY. Ireland. Improvements in, or relating to, batteries.

September 29, 1892.

17,381. J. MUIRHEAD. Glasgow. Improvements in, and relating to, telephonic instruments.

17,423. E. CHABEAULT. London. Improvements in apparatus for supplying electricity to electrically propelled vehicles.

September 30, 1892.

17,438. F. H. ROYCE, Manchester. An improved combined electro-motor and fan.

17,462. J. MEIR. Manchester. Improvements in, and apparatus for, moulding earthenware electric switches, ceiling roses, bell pushes, and the like, and forming screw threads thereon.

17,466. H. C. BULL and G. BARON DE OVERBECK. Liverpool. An improved electro-metallurgical process.

17,467. H. LEA. London. Improvements in driving sewing machines by electricity.

17,471. S. CONETER and H. NEHMER. London. Improvements in electrical motor and fan combined for filtering and fumigating the air.

October 1, 1892.

17,491. J. STEVENSON. Middlesborough. Improvements in the application of electricity to the human body.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

15,414. KELWAY. Electric lamps.

15,705. WATKINSON and PRINCE. Electric signalling on railways.

16,076. WRATITSCH and GERGACSEVICS. Coin-freed telephonic system.

17,192. WRIGHT. Electric distribution.

18,162. GOVER. Electrical lamp, &c., fittings.

18,595. HARRISON and BUDD. Electric meters.

19,198. NEW. Electric lamps.

19,211. TEAGUE and MOY. Electric meters.

19,450. MARSH and others. Electric apparatus.

19,625. GRUNDY. Electric lighting.

19,778. DAWBARN. Electric lighting apparatus.

19,854. DICKSON and SHAPCOTT. Dynamo brushes.

19,914. BARTON (Jandus). Electric arc lamps.

19,952. HOFFMAN. Magnetic separators.

20,139. GENT and others. Electric signals.

22,025. SMALLWOOD. Electric light fittings.

1892.

1,436. JOHNSON (De Bovet). Dynamo-electric, &c., machinery.

11,952. JONES. Electric meters.

13,562. YOUNG (Colgate). Electrical accumulators

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13,639. SIMPSON. Mechanical telephones.
14,044. FELL (Morrison). Secondary batteries.
14,189. LAKE (Stanley and another). Distributing electric currents.
14,588. DORMAN and SMITH. Incandescent electric lamps.
14,738. COERPER. Electric arc lamps.
14,822. LAKE (McOuat). Incandescent electric lamps.

COMPANIES' MEETINGS & REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended June 30th last, to be submitted to the thirty-eighth ordinary general meeting at Winchester House, E.C., on Wednesday, the 19th inst., at 12 o'clock :—

The revenue for this period amounted to £111,870. 4s. 4d., and the working expenses to £29,557. 6s. 10d. After providing £12,880 for debenture interest and sinking funds, and £752. 14s. for income-tax, there remains a balance of £68,680. 3s. 6d. ; to this is added the sum of £19,893 4s. 11d. brought forward from December 31st last, making a total of £88,573 8s. 5d. A quarterly interim dividend, amounting to £19,500, has been paid, and £40,000 transferred to the reserve fund, increasing that fund to £579,714. 6s. 1d.

The Directors now recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total dividend of 6 per cent. for the year, and also the payment of a bonus of 1s. per share, both free of income-tax, which, together, will amount to £26,000, leaving a balance of £3,073. 8s. 5d. to be carried forward. The dividend and bonus will be payable on the 20th instant.

On July 31st last the sum of £16,800 was transferred to pay off the 168 bonds of the 1884 Issue, drawn for redemption in April last. This repayment reduces the debenture debt to £111,400.

The receipts for the half-year include the sum of £1,500 dividend to December 31, 1891, on the Company's shares in the African Direct Telegraph Company (Limited).

The Western and Brazilian Telegraph Company's Santos-Chuy Section was duplicated on June 7th last, thus completing the duplication of the whole of that Company's system from Pernambuco to Monte Video, and giving a direct telegraphic service by duplicate cables between Europe and the River Plate.

The various sections of the Company's line are in good working order.

Sir Henry D. Gooch, Bart., and the Duke de Loulé retire by rotation at this meeting, and, being eligible for re-election as Directors, offer themselves accordingly. The auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

AKESTER ELECTRIC SYNDICATE (LIMITED).—This Company was registered on October 5th, with a capital of £15,000, in 300 shares of £50 each, to carry into effect a provisional agreement, dated June 29, between William H. Akester, of 11, Ward's-avenue, Fulham Palace-road, London, S.W., electrician, of the one part, and Patrick R. Low (as agent for the Company), of the other part, for the acquisition by the Company of the patent No. 7,718, of 1892, for "Improvements in Electric Arc Lamps," to acquire by purchase, lease, licence, or otherwise, and to use, develop, and turn to account, any other patents, patent rights, inventions, machinery, appliances, and anything in any way connected with electric or magnetic appliances for lighting buildings, works, streets, &c., railway, or other carriages, for heating railway or other carriages, or buildings, for providing motive power, or for stopping vehicles or other bodies in motion ; for working railway or other signals, and for working and moving points and crossings on railways and elsewhere, and to carry on the business of electricians, electrical, and mechanical engineers, suppliers of electricity, &c. The subscribers are (with one share each) : C. T. Praed, 24, Cadogan-place, S.W. ; Lieut. A. R. Dick, Cedarlea, Surbiton, S.W. ; Charles P. Johnston, Annandale, Streatham Common, S.W. ; Francis Skipworth, Red Cottage, Harpenden ; W. H. Akester, 11, Ward's-avenue, Palace-road, Fulham, S.W., electrician ; Francis R. Hill, 116, Wandsworth-road, S.W. ; H. H. Price, 9, John-street, Adelphi, W.C. The number of Directors is not to be less than three nor more than six, the first being Charles T. Praed, Arthur R. Dick, and one other person to be nominated by the subscribers.

GENEVA SCREW AND RIVET COMPANY (LIMITED).—This Company was registered on October 4th, with a capital of £3,000, in £1 shares, to acquire and carry on the business of screw, rivet, and bolt manufacturers, mechanical and electrical engineers, electricians, &c., carried on by D. Barnett and J. A. Cooke, under the style of "Barnett and Cooke," at Colley-street, West Bromwich, Staffs.

J. R. POWDITCH AND CO. (LIMITED).—This Company was registered on October 6th, with a capital of £4,000, in £10 shares, to acquire, take over as a going concern, and carry on the business of shop fitters, electrical engineers, electric light contractors, carpenters, plumbers, gasfitters, &c., carried on under the style or firm of J. R. Powditch and Co., at 9½ Percy-square, King's Cross-road, W.C. Registered office : 16, St. Helen's-place, E.C.

SCHIELE UNION ENGINEERING COMPANY (LIMITED).—This Company has been registered, with a capital of £12,000, to acquire, take over as a going concern, and carry on the business of mechanical, electrical, and general engineers, iron and brass founders, &c., carried on by the Union Engineering Company (Limited).

TAWE FOUNDRY AND ENGINEERING COMPANY (LIMITED). — This Company was registered on October 4th, with a capital of £2,000, in £5 shares, to carry on at Llansamlet, Glamorgan, the business of mechanical and electrical engineers, machine and engineering tool makers, boiler makers, &c.

YOUNG'S REVERSIBLE NUT LOCK SYNDICATE (LIMITED) — This Company was registered on October 6th, with a capital of £12,500, in £5 shares. The objects are to acquire, develop, and turn to account a certain invention for "improvements in locking nuts on bolts used in fastening fishplates on the rails of railroads and for like purposes," and to carry on the business of ironmasters, boiler makers, steel makers, ironfounders, mechanical, electrical, and general engineers, public works, contractors, &c.

BRIGHTON AND HOVE ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to August 23rd, was filed on September 29th. The Company was registered as the Brighton Electric Light Company (Limited) on December 16, 1885, with a capital of £25,000, in £5 shares, to acquire the electric lighting works and plant at Brighton carried on by the Hammond Electric Light Company (Limited), and in consideration for the said electric works the Company issued 1,600 shares, on each of which £3. 15s. was considered as paid, to Robert Hammond. In December, 1888, the name was changed to the present title, and the capital was raised to £100,000 by the creation of 15,000 new shares of £5 each. At the time of making up, 3,000 shares had been taken up, of which 1,600 had been issued with £3. 15s. per share paid. Upon the same shares the remaining £1. 5s. had been called, and upon 1,400 the full amount had been called, the calls paid amounting to £9,000.

BUENOS AYRES ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to June 22nd, was filed on September 19th. The Company was registered on November 12, 1881, with a capital of £100,000, divided into 9,986 ordinary shares of £10 each and 70 shares of £2 each. At the time of making-up, the 70 founders' shares had been taken up, no calls being made. The present shareholders are the original signatories to the Memorandum of Association.

NATIONAL TELEPHONE COMPANY (LIMITED).—By agreements filed September 26th the National Telephone Company have agreed to give £4,675 for the telephone business of the Caledonian Telephone Company (Limited), the vendor Company agreeing to accept 935 fully-paid shares in the National Company in full satisfaction of the purchase consideration ; and the National Telephone Company (Limited) have agreed to purchase all the business, goodwill, patents, cash rights, privileges, and other property of the Western Counties and South Wales Telephone Company (Limited) (except the licence granted by the Postmaster-General in 1885) for the sum of £11,236. 17s. 4d.

PONTYPOOL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The statutory return of this Company, made up to August 11th, was filed on September 24th. The Company was registered on March 28, 1892, with a capital of £10,000 in £5 shares. At the time of making up, 280 shares had been taken up, no calls being made.

R. C. CUTTING, DOUGLASS AND COMPANY (LIMITED).—The statutory return of this Company, made up to September 22, was filed on October 1. The Company was registered on May 11, 1892, with a capital of £20,000. At the time of making up, 2,050 shares were taken up, of which 1,972 had been issued as fully paid. Upon 64 of the remainder the full amount had been called, and upon the remaining 14 shares, £2. 10s per share had been called, resulting in the payment of £327. 10s. leaving £27. 10s. in arrears.

RIVER PLATE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to June 30, was filed on July 9. The Company was registered on February 7, 1889, with a capital of £500,000, divided into 49,900 ordinary shares of £10 each, and 1,000 founders' shares of £1 each. At the time of making up, 13,557 ordinary and 892 founders' shares have been taken up, of which 2,400 ordinary shares had been issued as fully paid. Upon the remaining 11,157 ordinary and 892 founders' shares the full amounts have been called resulting in the payment of £110,892, leaving £1,570 as yet unpaid.

CITY NOTES, &c.

CALLS DUE.—*Oct. 30 :* NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED), £2 on 2,998 £10 shares. *Oct. 31 :* ISLINGTON AND GENERAL ELECTRIC SUPPLY (LIMITED), £1 on 45,000 £5 shares ; NEW TELEPHONE COMPANY (LIMITED), £2 on 48,800 £10 ordinary shares.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to appoint a settling day in, and to grant a quotation to 20,000 Six per Cent. Preference Shares in this Company.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 9th were £859, as against £747 for the corresponding period of last year, being an increase of £112. The

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total receipts for half-year amount to £11,616, against £10,621 in the corresponding period of 1891, being an increase of £995.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Board have resolved upon the payment of an interim dividend of 3s. 6d. per share, free of income-tax, being at the rate of 3½ per cent. per annum, for the quarter ended September 30, 1892, such dividend to be payable on and after the 24th inst.

MESSRS. CROMPTON AND CO. (LIMITED).—Applications have been advertised this week for £110,000 further capital, in 22,000 ordinary shares of £5 each, payable 10s. on application, 10s. on allotment, and the balance in calls of not more than £1 per share, and at intervals of not less than two months. The list closed yesterday (Thursday).

NATIONAL TELEPHONE COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to allow 1,135 ordinary shares in this Company, Nos. 447,235 to 447,434 and Nos. 453,813 to 454,747, to be quoted in the Official List.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Oct. 7, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,851.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 5.	Price Wednesday, Oct. 12.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 12.	
						£ s. d.		Highest.	Lowest.
			TELEGRAPHS						
£1,247,720	Stock	12/6	Anglo-American	49 50	50 51	5 5 10	Jan., Apr., July, Oct.	50½	49½
£2,876,140	Stock	25/0	Do. Preferred	90 91	91 92	5 16 3	" "	91⅝	90½
£2,876,140	Stock	5/0	Do. Deferred	10 10½	10⅞ 11¼	..	" "	11⅛	10½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11 11½	10⅞ 11	6 4 5	Mar., June, Oct., Dec.	11¼	10⅞
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1¼	Commercial Cable Capital Stock	168 173	168 173	4 0 11	Jan., Apr., July, Oct.	170½	170
16,000	10	8/0	Cuba Submarine	11½ 12½	11¼ 12½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17½ 18½	17½ 18½	5 8 1	" "	18	..
12,931	5	1/7½	Direct Spanish (£4 paid) xd	3½ 3¾	3½ 3¾	4 16 9	April and October	..	..
6,000	5	10%	Do. Preference 10% xd	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅞ 12	11⅞ 12½	5 15 5	Jan., Apr., July, Oct	12	11⅞
400,000	10	5/6	Eastern	14⅞ 15⅛	15 15¼	4 5 3	" "	15 7/16	15
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16	15½ 16	3 15 0	" "	16	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111 114	111 114	3 10 2	May and November	113½	112½
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109	106 109	4 11 9	February & August	109½	..
250,000	10	2/6	Eastern Extension	15½ 15¾	15⅝ 15⅝	4 9 7	Jan., Apr., July, Oct.	15 7/16	15⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	109 112	109 112	3 11 5	February & August	111	110
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103 106	103 106	3 15 6	February & August	..	..
180,227	10	3,9	Globe Telegraph and Trust	10½ 10¾	10½ 10¾	4 12 4	Jan., Apr., July, Oct.	10⅝	10⅜
180,042	10	6%	Do. 6 per Cent. Preference	15⅜ 15⅝	15⅜ 15⅝	3 16 10	" "	15⅝	15⅜
150,000	10	5/0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	42 44	43 45	5 11 1	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 103	105 108	5 11 1	March & September	..	..
10,802	8	8/0	Reuter's	7 8	7 8	5 0 0	April and October	..	..
3,381	£100 Cert.	£1⅞	Submarine Cables Trust 6%	116 121	116 121	4 19 2	" "	..	..
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July	3½	3
£150,000	100	8%	Do. Debentures 8% 1902	103 107	103 107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama	1 1½	1⅛ 1⅜	..	" "	1 1/16	1 1/16
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 9¾	9½ 10	6 0 0	May and November	9⅝	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8⅞ 9⅛	6 6 4	" "	8⅞	8⅝
64,242	15	6/0	Western and Brazilian	8½ 9	8½ 9	6 13 4	" "	8⅝	8⅜
33,129	7½	1/8	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 3	" "	6½	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2½ 3	2½ 3	..	" "	2⅝	2⅜
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123 128	123 128	5 9 5	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
40,000	£5	10/0	Chili Telephone	.. ..	.. ..	3 4 0	..	3 1/16	..
22,500	15/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜	⅛ ⅜	6 10 10	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	1/16 5/16	5/16 7/16	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅜ 4⅝	6 3 1	June and December	4⅝	4 11/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13⅜ 14½	13⅜ 14½	4 4 3	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13½ 13⅞	13½ 14	4 5 9	" "	13⅞	13⅜
220,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	111 113	111 113	3 19 8	January and July	112⅝	..
48,000	£10	..	New Telephone, Limited (£2 paid)	1 1½	1½ 2	..	..	1⅜	1 1/16
58,000	5	1/0	United River Plate	1¾ 2¼	1¾ 2¼	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	—	—	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	10 10½	10¼ 10⅜	..	—	10⅜	10¼
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	—	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	—	..	..
8,332	£5	..	House to House Electric	.. ..	.. ..	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	.. ..	.. ..	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	5 4 4	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 10s. paid)	3 1/16 3 3/16	3 1/16 3 3/16	3 15 9	March	..	..
10,000	£5	4½%	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	4 6 9	March	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7	6½ 7	..	..	6⅞	6⅞
£50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	103 105	4 15 3	June and December	105	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½ 5½	4½ 5½	—	—	..	..
18,680	£5	2/6	St. James' and Pall Mall	7¾ 8¼	7¾ 8¼	—	—	8	..
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	..	—	8½	..
42,853	5	3%	Westminster Electric Supply (fully paid)	6 6½	5¾ 6¼	2 8 0	—	6⅛	5⅞
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/9	Brush Electrical Engineering	2¾ 3¼	3 3⅜	..	—	3⅜	3
69,996	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2 1/16	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5¾	5 5⅛	6 7 3	January and July	5 1/16	5
12,139	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	3⅛ 4	3⅜ 4⅛	..	—	4⅛	3⅝
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅛ 2⅜	2 2⅛	—	—	2 1/16	2⅛
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha & c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/9 4/3	3/9 4/3	..	..	..	..
78,949	5	2/9⅓	Swan United (£3. 10s. paid)	3½ 4	3½ 4	9 12 6	May and November	3⅞	..
37,350	12	12/0	Telegraph Construction and Maintenance	44 46	44 46	5 4 4	March and July	45½	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	—	..	..
—	£5	8%	Do. Preference (fully paid)	.. ..	.. ..	..	—	..	..
			RAILWAYS AND TRAMWAYS.						
50,000	£10	½%	City and South London Railway	2⅛ 3⅛	2⅛ 3⅛	1 8 6	—	..	..

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THE ELECTRICIAN:

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NOTES.

The case of the Edison Electric Light Company *v.* The United States Electric Lighting Company, which has been before the Law Courts of the United States for about five years, has at last been brought to a close by a decision of the Circuit Courts of Appeal, who give Edison the full credit for having devised and made the first practicable carbon lamp. The judgment goes carefully into the state of knowledge prior to 1879, confining this, however, for the most part to American doings, for no mention whatever is made of the name of Swan. Most of our readers who take the smallest interest in the history of electric lighting are aware that Mr. Swan experimented in 1877 with carbonised paper in a glass bulb, the connection being made with platinum wires. The earliest attempts had been made in 1848, but the work was put on one side until Mr. C. H. Stearn, who was skilful in the use of the Sprengel pump, lent his assistance. The experiments were carried on almost continuously until a lecture was delivered in Newcastle in February, 1879, when true carbon glow lamps were shown. Mr. Swan, as we observed last week, did not apply for any patent until January 2, 1880.

The step from Swan's paper filaments to the really tolerable and commercial ones of Maxim was a far smaller step than from the tar-putty spiral of Edison to his bamboo lamp which was patented on September 16, 1880. Swan had hit on carbon by a kind of inspiration, based, no doubt, on his knowledge of chemistry. Edison, like Lane-Fox, began with platinum, and, thanks to the *New York Sun* and the *New York Herald*, started a craze which neither the platinum lamp nor the modification of it could support. The tar-putty filament did not probably assist matters very much, it indicated the abandonment of platinum, but Edison had made such extravagant promises, that he was bound to go on until he achieved success. The indomitable perseverance of the man was equal to the task, and the bamboo lamp proved to be an excellent one.

Although the name of Swan does not appear in the judgment of the U.S. Appeal Court, some cognisance is taken of foreign affairs, for Edison's French patent of May, 1879, is repeatedly alluded to, and reference is made to Lane-Fox's various patents. This American case was really concerned with the patents and not with mere inventions. It may be fair to say that this patent of November 4, 1879, was the first indication so far as the American Patent Office is concerned, of the use of carbon in an incandescent lamp. This has been sufficient to win the case. But Edison's really useful work was only then just beginning. The real credit due to him is for perfecting the lamp with the assistance, no doubt, of the work of others, in such details as flashing, mounting, and exhausting.

The phenomena attending the blackening of the bulbs of glow lamps have formed the subject of an interesting investigation at the Cornell University, and a description of the experiments by Prof. Nichols is given in our present issue. The chief result is that the falling off of candle-power with age is due to a change of the filament, and not, to any large extent, to absorption of light by the film formed on the glass. The fact that the film absorbs all kinds of light equally is interesting in itself.

There are only three sources from which the blackening can come—the residual gases, the jointing material, or the filament itself. That there is very little residual gas is, of course, evident, but it has been alleged that the blackening takes place to a much smaller extent in lamps which have been exhausted without the use of mercury. Mercury may then have some direct or indirect connection with the "age-coating." Whether the blackening comes out of the joint or no could be easily settled. In some lamps the joint is less thoroughly carbonised than the rest of the filament. If, lastly, the deposit is due merely to a condensation of carbon vapour volatilised from the substance of the filament, the diameter of the filament may or may not become reduced. It is not improbable that the more volatile parts are driven off first, but there is no evidence to show that old filaments are rotten or porous rather than thin. In either case the resistance would, of course, be increased, and in a certain sense the current density would remain constant. If a mere thinning takes place, as the lamps are fed at constant voltage, the current density in the filament must remain constant, the sectional area diminishing in proportion to the current.

Dr. Fleming has called attention to the fact that the filament sometimes casts a transparent shadow on the glass, the particles being bombarded in a straight line, owing to the vacuum. Prof. Nichols' curves of candle-power in different azimuths would not show any indication of this, for just at this point one side of the filament is hidden by the other, but no mention is made by Prof. Nichols of such a shadow.

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According to a note in *L'Industrie Electrique* a new type of flashing light for lighthouses has been designed by M. Bourdelles, the engineer-in-chief of the lighthouse service of France. It is claimed that with 20 mm. carbons and an optical system of four panes, about two feet in diameter, a considerably better effect can be obtained than with the heavy and costly optical arrangements used in this country with carbons of 50 and 60 mm. No indication is given of the details, and the performance is estimated rather vaguely in millions of *becs*. The photometry of lighthouses is of course a very difficult matter, and the power of the lamp should be estimated independently of the optical apparatus. It is possible that a 20 mm. carbon might be made to give as much light as the 50 or 60 mm. carbons used at St. Catherine's Point, if the light-giving surface were properly utilised.

Speaking of wall-sockets, on which we have made some observations in another column, reminds us of the flexible cord which is used in connection with these fittings. Unless of really good quality and well cared for, this is likely to be a weak point in the insulation of house wiring. The rule that fuses should be fixed wherever the size of a conductor is reduced, to protect the smaller wires, is often neglected in the case of wall-sockets. The flexible wires are practically the only conductors in a house which are liable to be short-circuited, and on this account alone they ought to be well looked after. All that is wanted is a fine fuse which is sure to go before the wires can become heated. We experienced very unpleasant burns from a short circuit in a switch on a portable lamp some years ago, the flexible wires becoming red hot before the fuse went, and we heard of a similar accident only a week ago. Fuses, however, have been greatly overdone, and Mr. Preece has called attention to the absurd number of unnecessary dry joints which are thus introduced in some cases.

The flexible cords for portable lamps and pendants are commonly made up of 25 or 30 or more strands of No. 38 or 40 S.W.G., and not the least valuable part of the covering is a layer of soft cotton, beneath which pure rubber is generally to be found, A cord composed of 25 strands of No. 40 S.W.G. has only the same sectional area of copper as a single No. 23, a much smaller size than is ever used in wiring, and yet fuse wire of about No. 20 is often used, because, no doubt, it will protect the ordinary wiring, and, perhaps, because fine fuse wires are expensive. No records have yet been published, and we are not aware that experiments have been made, on the carrying capacity of these flexible wires. If any of our readers can give figures we shall be glad to publish them. The limit might be put at the current which would raise the resistance of the conductor 15 per cent., corresponding to a rise of 70 degrees Fah., or about half-way to boiling point.

The suggestion made by Mr. Duncan in our Correspondence columns for printing exponents without troublesome "leading" leaves nothing to be desired from the printer's point of view, but the vertical lines which he proposes to use do not suggest the elevation of the index. Mr. Mitchell's reversed solidus meets this objection, and, when the exponent is enclosed in brackets, this symbol might be employed with advantage.

Prof. S. P. Thompson's letter, which has given rise to this discussion, was directed to remove difficulties between authors and printers rather than to avoid trouble and expense in setting the type, but since this side of the question has been raised, it may be observed that the line or vinculum below the small type in Mr. Mitchell's alternative suggestion gives considerable trouble; quite as much, in fact, as when larger type is used and the line is specially "leaded." With regard to the use of brackets and the solidus, although this may be considered to be no alteration of the author's text, to use it without his consent might sometimes be regarded as an unwarrantable liberty.

We were rather shocked to receive from the Electropathic and Zander Institute a copy of a report by Dr. A. Harries upon Harness' belts. We received a similar report some time ago by a Dr. Tibbits, of whom we know nothing, and which, therefore, we did not trouble to notice. Dr. Harries was, however, connected with a venture which we recently described as an honest attempt to apply electrical treatment with care and intelligence, and we greatly regret to find that he has associated himself with a concern which certainly cannot be described in the same terms. A glance through the report shows, however, as might have been expected, that Dr. Harries does not commit himself.

We alluded some little time ago to the fact that the exact nature of that which we have provisionally agreed to call electricity was no longer merely a question for ingenious scientific theorising, but had occupied the attention of the Law Courts both in France and America. In the State of New York the Court of Appeal has, to speak in the language of that part of the world, "rendered a decision" exempting electric lighting companies from taxation on the ground that they are engaged in the *manufacture* of—electricity. Still more recently the question as to whether electric lighting companies are manufacturing concerns has been considered by the Supreme Court of Alabama in the case of Beggs against the Edison Electric Light and Illuminating Company. In Alabama it has been sensibly declared that it is useless to argue that electricity is "a free gift of nature gathered from the clouds"; electricity as delivered to a consumer's lamps must be deemed a product of capital and labour and indistinguishable from a manufactured article. The Court remarked, by the way, that the collection, storage, preparation for market and distribution of ice as found in nature was not manufacturing, but the production of ice by artificial means was. By analogy, we presume, an individual getting shocks from a kite would not, whilst any one doing so by means of a magneto-machine would be, a manufacturer. Again, if central station dynamos received their initial excitation from a loadstone the "free gift of nature" argument would probably be held valid.

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Bath.—On the 29th ult. all the users of the electric light in Bath were supplied with meters.

Electric Traction in France.—An electric tramway on the Sprague system is to be constructed at Gênes.

The Telephone in Russia.—It is stated that the Russian Government is about to purchase the telephone system.

Bolton.—The Town Council have decided that the town shall be supplied with the electric light. The system adopted is to be also capable of running the trams.

The Fiske Range Finder.—The Elliott Cresson Gold Medal has been awarded by the Franklin Institute to Lieut. Fiske, the inventor of the Fiske electrical range finder.

Personal.—Mr. Faraday Proctor, second engineer to the Newcastle-on-Tyne Electric Supply Company, has been appointed clerk of the works to the Bristol central station. The salary is £250 a year. There were between 40 and 50 applicants.

Westinghouse Incandescent Lamp.—The Westinghouse Electric and Manufacturing Company state that they are now prepared to receive orders for their new incandescent lamp. This lamp is, of course, said not to infringe the Edison or any other patent.

Institution of Electrical Engineers.—The annual dinner of the Institution will take place on Friday, November 18th, at the Criterion Restaurant. We are glad to learn that it is intended to curtail the speeches, and to adjourn at a comparatively early hour to the smoking-room.

Hampstead Vestry.—At the last meeting of this Vestry it was decided that the London and Hampstead Battery Company should be informed that they could not be allowed to lay wires underground instead of overhead, as the Vestry had obtained their own Provisional Order for supplying electricity in the parish.

Forthcoming Books.—Messrs. Whittaker and Co. will issue next week a new work by Mr. Allsop, entitled "Practical Electric Light Fitting." The work will be fully illustrated. They expect to have ready also Part I. of Mr. Maycock's new "Elementary Manual of Electric Lighting and Power Distribution."

Electrical Communication with Lighthouses.—The Royal Commission upon Electric Communication with Lighthouses and Lightships resumed its sittings on Wednesday and yesterday. The evidence of Captain Halpin, Mr. Bedwell, and Mr. W. Smith, of the Telegraph Construction and Maintenance Company, was received.

Blackpool.—Mr. John Hesketh writes that, in our issue of October 7th, an error made by the local Press was carried forward by us. It was reported that the same dynamos would be used both for the tramway and the lighting. This, it seems, is an error. What it is intended to do is to work both the trams and public lighting from the same station.

Old Students' Association.—The annual dinner of this Association will be held on Friday, October 28, at 7:30 p.m., at the Holborn Restaurant. The reception by the President will begin at 7 p.m. Tickets (price 5s. each) may be had from any member of Committee, or on application to E. B. Vignoles, Hon. Sec., 28, Lanhill-road, Elgin-avenue, W.

Windsor.—The Windsor and Eton Scientific Society propose holding their annual *soirée* in conjunction with the inauguration of the electric lighting of the Royal Borough. The ceremony will take place in December, and it is intended that the chief feature of the evening shall be an exhibition of electrical and magnetic apparatus. Persons wishing to exhibit should apply for particulars to Dr. J. W. Gooch, 9, High-street, Windsor.

Oxford.—The lamp-posts fixed at the top of St. Ebbe's and near the Martyrs' Memorial and other places by the Oxford Electric Company were manufactured of wrought iron at Munich for the Company, with the special object of suiting the architectural character of the City. The remainder have been manufactured by the Electric Construction Corporation, of Wolverhampton. The lamp-posts are said to compare very favourably with those erected in the City.

Electrical Trade Section.—The following are the agenda of the meeting of the Electrical Trade Section which will be held this afternoon at 3 p.m. :—(1) minutes, (2) Chicago Exhibition and report of action of Chamber, (3) County Council overhead wires and correspondence, (4) London Chamber of Arbitration and action of Chamber in regard to electrical section, (5) standardising of machinery, (6) uniformity of prices, (7) foreign competition, and (8) other matters.

The New York-Chicago Telephone Trunk Line.—This much-talked-of line was experimentally inaugurated on Tuesday, and on Wednesday was opened for business, the charge for five minutes' conversation being 38s. The newspapers state that speech is distinct, though not particularly loud. The distance is 950 miles, making it the longest telephone line in existence. The London-Paris line is 311 miles in length, and the distance between Paris and Marseilles is about 450 miles.

Birmingham.—At a meeting of the General Purposes Committee of the Birmingham Corporation on Monday the principal subject discussed was the notice by the Birmingham Electric Supply Company of their intention to apply for an additional Order extending the area over which they have powers. It is understood that it was decided to postpone the consideration of the Order for twelve months. At a later stage the committee will consider whether or not they will recommend the Council to promote an Order for electric lighting on behalf of the Corporation.

The South Staffordshire Tramways.—The South Staffordshire Tramway Company made arrangements about twelve months ago for the introduction of the overhead wire system of electric traction on their lines between Wednesbury, The Pleck, Walsall, and Bloxwich. The Pleck, James Bridge, and Darlaston section will be completed in a fortnight or three weeks. It is proposed to run 14 cars. It is anticipated that towards Christmas the service will be greatly increased, and also that the new system will shortly be adopted on the Company's other lines. The generating station has been erected at James Bridge, near Darlaston. The trolley wire is carried on iron posts, at a height of 21ft. from the roadway. The pressure, which will at first be employed, is only 300 volts. Two 15-B.H.P. are fitted to each car.

Kelvinside.—As reported in our issue of September 2nd, the "feuars" of Kelvinside have taken a decided objection to the chimney of the Kelvinside Electricity Company. The secretary of the Company has recently addressed a reply to the remonstrances of the "feuars," in which he states that he is instructed by his Directors to say that the site upon which the works are to be erected was the only available site; that the plans of the works were prepared by Mr. Munro, an electrical engineer of good standing, and were submitted to and approved by Lord Kelvin and Dr. J. T. Bottomley, the consulting engineers of the Company; that the erection of a stalk was found to be absolutely necessary; that the best known appliances for the consumption of smoke will be adopted in the construction of the works; and that the works will be carried on in such a way as to be in no degree detrimental to the amenity of the district. He is also instructed to say that his Directors fully recognise that it is their duty to carry on the works in such a manner as to be in no way offensive. They have, accordingly, given instructions for 40ft. to be taken off the height of the chimney, and for the saving in the cost of building being applied towards making the chimney of a more ornamental character.

Carlow.—In connection with the note on the reported action of the Carlow Gas Company in regard to electric light consumers, which appeared on page 550 of our issue of Sept. 23rd, the following letter from the Secretary of the Gas Company, addressed to the *Journal of Gas Lighting*, will be of interest :—

SIR: In regard to your reference to this matter in the *Journal* for the 4th instant, I may say that there is no truth whatever in the statement that the Carlow Gas Company issued a circular to the inhabitants of Carlow, informing them that "any person using electric light would be at once cut off from the gas mains." No such circular was issued, or any order to that effect. A few persons using electric light, and who had ceased to use gas, were served with notice that their meters would be removed; but this they refused to allow—it being very useful to have the gas when the electric light goes out, as it does very often. For instance, it was out for half-an-hour on the 13th inst. The electric light is on only from sunset until 12 o'clock p.m. I may add that 14 out of 203 consumers have taken in the electric light on trial; and this is the extent of the success of the Electric Light Company in Carlow. Th

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Carlow Gas Company are under deed of settlement, and not under Act of Parliament; and they are, therefore, in no way bound to leave meters with non-consumers, except by courtesy.

The Central Institution.—Of the 109 candidates who recently entered for the matriculation examination at the Central Institution, 73 passed, and 6 did sufficiently well to be allowed to join the College as unmatriculated regular students. In addition to these 79 thus admitted each to attend courses in all the four departments of mathematics and mechanics, engineering, physics, and chemistry, and those who, having entered in previous years, have not yet completed their course, some 40 special students have joined the advanced courses in one or more of these departments, thus bringing the total number of students at the Central Institution up to the maximum for which it was intended. On the result of this entrance examination the Clothworkers' Scholarship of £60 a year, with free education for two years and renewable for a third, was gained by W. G. Bennett, from the Bancroft School; the Mitchell Scholarship of £30 a year for two years with free education by E. W. Hummel, from the Finsbury Technical College; the Clothworkers' Technical Scholarship of £25 a year for two years at the Finsbury College, and £30 a year for three years at the Central Institution, both with free education, by W. C. Mears; and four Institute's Scholarships of sufficient value to cover the fees for three years by M. J. P. O'Gorman (from the Royal University, Dublin), W. T. Gidden (Bancroft School), and A. D. Constable and W. A. Davis (both from St. Dunstan's College, Catford). At the end of the last session the John Samuel Scholarship of £30 and free education for a third year's student was awarded to H. C. Leake, and the Siemens Medal to C. V. Drysdale.

The Commercial Accumulator.—Under this heading M. P. Vitte, engineer to the Lyons Gas Company, in *L'Industrie Electrique* for October 10th, sings, at considerable length, the praises of the Tudor accumulator as a central station auxiliary. For central station work M. Vitte is of opinion that the pasted cell is more bother than it is worth, and points out that for this purpose a high-capacity cell is not so much wanted as one which will without subsequent injury to itself yield upon an emergency currents far above the normal, and which does not require careful and minute inspection and frequent repairs. The objection that cells of the Tudor become in time *hors de combat*, owing to the positives oxidising through, is, according to M. Vitte's experience, without foundation, and he cites the case of a plate which after being eight years in work had only a ·2 to ·3 mm. layer of oxide. The capacity of the Tudor plate, although admittedly less than that of pasted plates, is not, M. Vitte points out, so low, when compared with plates of the Faure type, as one would at first sight suppose, since the plugs of Faure plates are but indifferently utilised. The Tudor battery at the central station belonging to the Lyons Gas Company has been in use for 28 months, and has needed no kind of repair. In practice, M. Vitte finds it an easy matter to obtain an average energy efficiency of 85 per cent., and thinks that even under unfavourable conditions an 80 per cent. efficiency should not be out of the question. The Tudor plates are solid lead, superficially scored, the horizontal grooves being filled with paste; after a time the paste falls off, and we have a superficial oxidation of the entire plate.

The Telephone in Switzerland.—The Geneva correspondent of the *Economiste Français* states that the increase in the number of telephone lines since the new tariff came into operation, about two years ago, has been very remarkable. Previous to that there were 61 telephone exchanges, with 6,944 stations and a revenue of about £44,000, the annual subscription being £6, with no limit to the number of conversations. The new tariff lowered the subscription to £3. 4s. (80fr.), and the result is that at the beginning of the present year there were 101 telephone exchanges, with 12,595 stations, this being equivalent to an increase of 81 per cent. The length of line is 3,225 miles. The principal exchanges are:—Geneva (2,176 stations), Zurich (1,712), Basle (1,522), Lausanne (806), Berne (753), and St. Gall (596). The new law stipulates that each subscriber shall be entitled to only 800 conversations in the course of the year, and pay a halfpenny for each one over that number, but over 78 per cent. of the subscribers kept within the prescribed limits. Although the total receipts amounted to £65,400, the expenses incurred in putting down new lines and increasing the staff were so great that the net receipts were about 4 per cent. less than in the year previous to the passing of the new law, but for all that the profit derived by the State is so large that these expenses will soon be paid off, and a surplus will be available. The development of telephone communication has, as might be expected, checked the increase in telegraphic communication, the number of telegrams showing only a fractional increase upon those of the previous year, while it is anticipated that there will this year be an actual decrease.

The Indian Telegraph Department.—The regulations, which are the outcome of the recommendations of the Public Service Commission, for the future appointment of officers in India to the superior establishment of the Telegraph Department, from the Civil Engineering Colleges of India, have, says the *Indian Engineer*, been approved by the Secretary of State. A Provincial Service recruited in India will be established, on a rate of pay differing from that of the Imperial Service recruited in England. This service will be under the leave rules of the Indian Services, Chapter XIV., and under the General Pension Rules, Part 4, of the Civil Service Regulations. In all other respects there will be no distinction between the members of this service and those of the Imperial Service. No change will be made in the pay of the Director-General or Deputy Director-General, whether belonging to the Imperial or the Provisional Service. Directors will draw Rs.1,050 monthly, Superintendents Rs.850, Rs.675; Assistant Superintendents. Rs.475, Rs.275, and Rs.225, according to their classes and grades. Recruitment for the Provincial Service will be from students of the Thomason College at Roorkee. Students from other engineering colleges in India wishing to enter the Telegraph Department will be admitted to the Thomason College for training in telegraphy. Students must be natives of India, as defined in Statute 33 Vict. The number of appointments offered will ordinarily be two and one in alternate years, but these numbers may be varied according to the requirements of the Department. Candidates will undergo a course of training for two years at the Thomason College, and they will afterwards be appointed as apprentices, on Rs.100 monthly.

Electricity Supply in Paris.—Our esteemed contemporary *L'Industrie Electrique* publishes in its issue of October 10th a map of Paris showing the areas allotted to the different Electric Lighting Companies. The first concessions were granted in Paris in February, 1889, about a month or six weeks before Major Marindin opened his Inquiry at the Westminster Town Hall, and some six months before the Electric Lighting Provisional Order Bills relating to the metropolis received the Royal assent. The Paris companies thus had a slight start of our own, but the conditions imposed upon them were more onerous. The duration of the concessions was only 18 years; there was an annual tax of 100fr. per kilometre of conduit run, and a levy of 5 per cent. on the gross receipts. At the present moment five companies and the Municipality are at work, with a total plant capacity of about 9,500 kilowatts. Each company has a V-shaped district to itself, extending from the heart of Paris, and opening outwards to the fortifications. No company has as yet been started on the south side of the Seine. Two companies employ bare copper conductors, run in cement conduits; one, armoured lead-covered cables laid in sand; one, insulated cables laid in paraffined wood blocks placed in cast-iron troughs; one, concentric cables laid in sand; the Municipality using insulated cables run along the walls of the sewers, and also insulated cables laid in sulphated wood blocks placed in cement troughs. One Company, the Société Anonyme du Secteur des Champs Élysées, proposes to distribute alternating currents at 3,000 volts; the Compagnie Edison and the Municipality have adopted the 3-wire system, the latter with accumulators; the Société d'Éclairage prefers the plain 2-wire system with accumulators; the Société du Secteur de la Place Clichy employs the 5-wire system, with accumulators; and the Compagnie Parisienne distributes current on a peculiar storage-battery sub-station system of its own. The Municipality also employs alternating currents at 2,400 volts.

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ELECTROMAGNETIC THEORY.—XXXVIII.

BY OLIVER HEAVISIDE.

(*Continued from page 578.*)

§ 167. Thus, let us first abolish the intrinsic magnetisation of § 166, and substitute equivalent electric current. Here, by equivalent electric current, we mean a distribution of electric current which produces the same induction as the intrinsic magnetisation; so that if both were to exist together, the induction would be everywhere doubled; and then, if either of them were negatived, the resulting induction would be nil. That this is possible, whatever may be the distribution of inductivity, is a very remarkable property. The induction due to magnetisation is conditioned solely by the curl of the intrinsic magnetic force, and the "poles" are essentially quite a secondary matter. That is, we may vary the poles as we like, provided we do not alter the curl of the intrinsic force, without affecting the induction or the associated energy.

The question then presents itself whether this equivalence continues to hold good when the medium is set in motion past the stationary magnetisation or electric current respectively. In the circuital equation (64), put $\mathbf{h}_0 = 0$, and introduce a term $\mathbf{C}_0$ on the right side, producing

$$\text{curl}\,(\mathbf{H} - V\mathbf{Dw}) = \mathbf{C}_0 + cp\mathbf{E}, \quad . \quad . \quad . \quad (75)$$

expressing the first circuital law; whilst (65), or

$$\text{curl}\,(V\mathbf{wB} - \mathbf{E}) = \mu p\mathbf{H} \quad . \quad . \quad . \quad . \quad (76)$$

expresses the second. Now (75) only differs from (64) in the substitution of $\mathbf{C}_0$ here, for curl $\mathbf{h}_0$ there. That is, the new $\mathbf{C}_0$ and the old curl $\mathbf{h}_0$ are equivalent. We may, therefore, dismiss the idea of magnetisation, and let the source of the induction be any distribution of intrinsic electric current $\mathbf{C}_0$. With it is associated a certain distribution of induction, identical with that due to any distribution of intrinsic magnetisation for which we have curl $\mathbf{h}_0 = \mathbf{C}_0$, and the equivalence persists when the medium is moving, or when the sources are moving. Corresponding to (70) we shall have

$$\text{div}\,\mathbf{B} = 0, \qquad \mathbf{B} = \lambda\mathbf{F}, \qquad \text{curl}\,\mathbf{F} = \mathbf{C}_0/s, \quad . \quad (77)$$

for the determination of the induction in the eolotropic manner previously pursued, when the steady state of affairs is reached; subject also to the previous reservation that $\mathbf{w}$ and curl $\mathbf{B}$ are perpendicular. That is to say, the induction is affected by the motion in the same way as if the medium had its inductivity decreased from μ to μs in the direction of motion, without any change transversely, whilst at the same time the source $\mathbf{C}_0$ is effectively increased to $\mathbf{C}_0/s$.

Equations (77) are suitable when the electric currents are in planes perpendicular to the direction of motion. For instance, let there be (to take a very easy example) two parallel plane sheets of electric current of surface-density $\mathbf{C}_0$ and $-\mathbf{C}_0$ respectively. The induction between them, which is $\mathbf{B} = \mu\mathbf{C}_0$ when at rest, becomes $\mu\mathbf{C}_0/s$ when they are in motion with velocity u perpendicular to their planes. Here s is the fraction $(1 - u^2/v^2)$ as before, and the electric force accompanying the changed induction is simply the motional electric force.

There is another way of making the eolotropic comparison, namely, by employing the vector $\mathbf{f}$ instead of $\mathbf{F}$. Then, instead of (77) we shall have

$$\text{div}\,\mathbf{B} = 0, \qquad \mathbf{B} = (\lambda/s)\mathbf{f}, \qquad \text{curl}\,\mathbf{f} = \mathbf{C}_0. \quad . \quad (78)$$

In this way of looking at the matter we regard $\mathbf{C}_0$ as suffering no change of effective strength, whilst the eolotropic operator λ/s is such as to indicate increased inductivity (from μ to μ/s) transverse to the motion, and unchanged inductivity parallel to it. The vector $\mathbf{f}$ is the excess of the magnetic force $\mathbf{H}$ of the flux over the motional magnetic force. Inasmuch as this way emphasises the fact that the intrinsic sources are really constant, it is not without its advantages. But the idea of increased transverse inductivity is rather an unmanageable one in general, especially in the case of moving electrification.

If the sources and the medium have a common uniform translational motion, it may be seen from the general circuital equations that the steady distribution of the fluxes with respect to their sources is unaffected by the motion. That is, if we travel with the medium there is no change observable. This applies in the case of circuital sources (as curl $\mathbf{h}_0$ above), as well as divergent sources (as of electrification). The naturalness of the result is obvious, when the relativity of motion is remembered.

§ 168. It is now necessary to leave these special cases of eolotropy for fear of being carried away too far from the main subject, which is, the nature of linear vector operators, in termination of this chapter on vector analysis. Up to the present only the symmetrical operator has been under consideration. Three rectangular axes are concerned, each of which is identified with parallelism of the force and flux, or of a vector and a linear function thereof. Now, if we associate the algebraical ratio of the force to the flux with the three directions of parallelism, we see that the symmetrical linear operator depends upon three vectors. If they were arbitrary, this would involve nine scalar specifications; but, being coperpendicular, there are really only six independent specifications; and, moreover, if we transform to any other system of axes (independent or non-coplanar) there can still be no more than six independent data.

But it is easy to see that the general linear vector operator must involve nine scalar specifications, viz., three for each of the three independent axes of reference that may be chosen. Thus, let $\mathbf{D}$ be *any* linear function of $\mathbf{E}$. We must then have, in terms of the $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ components, the following set of equations:—

$$\left.\begin{aligned} \mathbf{D}_1 &= c_{11}\mathbf{E}_1 + c_{12}\mathbf{E}_2 + c_{13}\mathbf{E}_3, \\ \mathbf{D}_2 &= c_{21}\mathbf{E}_1 + c_{22}\mathbf{E}_2 + c_{23}\mathbf{E}_3, \\ \mathbf{D}_3 &= c_{31}\mathbf{E}_1 + c_{32}\mathbf{E}_2 + c_{33}\mathbf{E}_3, \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (79)$$

where the nine c's may have any values we please. The axes of reference are perpendicular only for convenience; any set of three independent axes may be used, with nine properly determined c's to match. The relation between the vectors $\mathbf{D}$ and $\mathbf{E}$, which is fully exhibited in (79), may be conveniently symbolised by

$$\mathbf{D} = c\mathbf{E}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (80)$$

where c is the general linear operator.

If we exchange c_{12} and c_{21}, &c., in the set (79) we shall usually change $\mathbf{D}$, of course. Let it become $\mathbf{D}'$. It is then fully given by the set

$$\left.\begin{aligned} \mathbf{D}'_1 &= c_{11}\mathbf{E}_1 + c_{21}\mathbf{E}_2 + c_{31}\mathbf{E}_3, \\ \mathbf{D}'_2 &= c_{12}\mathbf{E}_1 + c_{22}\mathbf{E}_2 + c_{32}\mathbf{E}_3, \\ \mathbf{D}'_3 &= c_{13}\mathbf{E}_1 + c_{23}\mathbf{E}_2 + c_{33}\mathbf{E}_3, \end{aligned}\right\} \quad . \quad . \quad . \quad (81)$$

and these relations between $\mathbf{D}'$ and $\mathbf{E}$ may be symbolised, like (80), by the single equation

$$\mathbf{D}' = c'\mathbf{E}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (82)$$

The manipulation of sets of equations like (79) and (81) is lengthy and laborious. By the use of the linear operators, however, with proper attention to the laws governing them, the vectors may be manipulated with facility. Thus, to give the first and easiest example that presents itself, we may *instantly* turn $\mathbf{AB}$ to $\mathbf{A}cc^{-1}\mathbf{B}$. This is obvious enough, inasmuch as the operation indicated by c^{-1} will be precisely cancelled by the operation c, so that $cc^{-1}\mathbf{B} = \mathbf{B}$. But there is much more in it than that. For $\mathbf{A}cc^{-1}\mathbf{B}$ is not merely the scalar product of the vectors $\mathbf{A}$ and $cc^{-1}\mathbf{B}$, that is, of $\mathbf{A}$ and $\mathbf{B}$, but is the scalar product of the vectors $\mathbf{A}c$ and $c^{-1}\mathbf{B}$, which are quite different. The vector $\mathbf{A}c$ is the same as the vector $c'\mathbf{A}$, whilst $c^{-1}\mathbf{B}$ is the vector which, when operated upon by c, gives the vector $\mathbf{B}$.

The constituents of the inverse operator c^{-1} may be found by solution of (79). Since $\mathbf{D}$ is a linear function of $\mathbf{E}$, it follows that $\mathbf{E}$ is a linear function of $\mathbf{D}$; or the E's may be expressed in terms of the D's by means of a set of equations like (79), with new coefficients instead of the c's there. Similarly as regards the inverse operator c'^{-1} belonging to (81) and (82).

The vector formed by taking half the sum of the vectors $\mathbf{D}$ and $\mathbf{D}'$ is a symmetrical function of $\mathbf{E}$, say

$$\tfrac{1}{2}(\mathbf{D} + \mathbf{D}') = \lambda\mathbf{E}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (83)$$

The constituents of λ with two equal suffixes, namely, c_{11}, c_{22}, c_{33}, are the same as those of c and of c'. But the other

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constituents are half the sum of the corresponding ones of c and c'; for instance $\frac{1}{2}(c_{12}+c_{21})$ in place of c_{12} and c_{21}. From this we see that the operator λ is its own conjugate, or is self-conjugate, making $\lambda\mathbf{E}$ and $\lambda'\mathbf{E}$ identical.

On the other hand, the vector formed by taking half the difference of $\mathbf{D}$ and $\mathbf{D}'$ is a simple vector product. By inspection of (79) and (82), and remembering the structure of a vector product, we may see that

$$\tfrac{1}{2}(\mathbf{D}-\mathbf{D}')=\mathrm{V}\boldsymbol{\alpha}\mathbf{E}, \quad . \quad . \quad . \quad . \quad . \quad (84)$$

where $\boldsymbol{\alpha}$ is the vector given by

$$\boldsymbol{\alpha}=\tfrac{1}{2}(c_{32}-c_{23})\mathbf{i}+\tfrac{1}{2}(c_{13}-c_{31})\mathbf{j}+\tfrac{1}{2}(c_{21}-c_{12})\mathbf{k}. \quad . \quad (85)$$

We see, therefore, that any linear function, if it be not already of the symmetrical kind, may be represented as the sum of a symmetrical function and of a vector product. Thus, by addition and subtraction of (83) and (84) we obtain

$$c\mathbf{E}=\mathbf{D}=\lambda\mathbf{E}+\mathrm{V}\boldsymbol{\alpha}\mathbf{E}, \quad . \quad . \quad . \quad . \quad (86)$$

$$c'\mathbf{E}=\mathbf{D}'=\lambda\mathbf{E}-\mathrm{V}\boldsymbol{\alpha}\mathbf{E}. \quad . \quad . \quad . \quad . \quad (87)$$

That is, in terms of the operators alone,

$$c=\lambda+\mathrm{V}\boldsymbol{\alpha}, \quad . \quad . \quad . \quad . \quad . \quad (88)$$

$$c'=\lambda-\mathrm{V}\boldsymbol{\alpha}, \quad . \quad . \quad . \quad . \quad . \quad (89)$$

where c (and therefore c') is general, whilst λ is symmetrical.

The vector $\boldsymbol{\alpha}$ is quite intrinsic, and independent of axes of reference. The symmetrical operator λ involves six scalars, the vector $\boldsymbol{\alpha}$ three more, thus making up the full nine.

Notice, by (86), (87), that

$$\mathbf{E}c\mathbf{E}=\mathbf{E}\lambda\mathbf{E}=\mathbf{E}c'\mathbf{E}, \quad . \quad . \quad . \quad . \quad (90)$$

or the scalar product of the force and the flux does not involve the vector $\boldsymbol{\alpha}$ at all.

§ 169. Now go back to the equations (79). Observe that the right members, being the sums of three pairs of simple products, are themselves scalar products. Thus, let three new vectors defined by

$$\left.\begin{aligned}\mathbf{c}_1&=\mathbf{i}c_{11}+\mathbf{j}c_{12}+\mathbf{k}c_{13},\\ \mathbf{c}_2&=\mathbf{i}c_{21}+\mathbf{j}c_{22}+\mathbf{k}c_{23},\\ \mathbf{c}_3&=\mathbf{i}c_{31}+\mathbf{j}c_{32}+\mathbf{k}c_{33},\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (91)$$

be introduced. Then we see that equations (79) are simply

$$\mathbf{D}_1=\mathbf{c}_1\mathbf{E}, \qquad \mathbf{D}_2=\mathbf{c}_2\mathbf{E}, \qquad \mathbf{D}_3=\mathbf{c}_3\mathbf{E}, \quad . \quad . \quad (92)$$

and, therefore, by combining them, we produce the *one* vector equation

$$\mathbf{D}=\mathbf{i}.\mathbf{c}_1\mathbf{E}+\mathbf{j}.\mathbf{c}_2\mathbf{E}+\mathbf{k}.\mathbf{c}_3\mathbf{E}, \quad . \quad . \quad . \quad (93)$$

thus proving that every linear operator may be exhibited in the dyadical form

$$c=\mathbf{i}.\mathbf{c}_1+\mathbf{j}.\mathbf{c}_2+\mathbf{k}.\mathbf{c}_3, \quad . \quad . \quad . \quad . \quad (94)$$

whether it be symmetrical or not. The conjugate operator is, similarly,

$$c'=\mathbf{i}.\mathbf{c}'_1+\mathbf{j}.\mathbf{c}'_2+\mathbf{k}.\mathbf{c}'_3, \quad . \quad . \quad . \quad . \quad (95)$$

where the accented vectors may be obtained from the unaccented given in (91) by changing c_{12} to c_{21}, &c., just as $\mathbf{D}'$ was got from $\mathbf{D}$, in fact.

It is now easily to be proved that

$$c\mathbf{E}=\mathbf{E}c', \qquad \mathbf{E}c=c'\mathbf{E}, \quad . \quad . \quad . \quad (96)$$

that is, if we wish to remove an operator from before to behind a vector, we may do so by simply turning the operator to its conjugate; that is, by putting on the accent, or by removing it if already there. It will, of course, be understood that when a vector $\mathbf{E}$ follows c, and we use the dyadical form of c, as in (94), it is only the three second vectors that unite with $\mathbf{E}$; whereas, if $\mathbf{E}$ precedes c, it is the first vectors in c that unite with it. Thus:—

$$\mathbf{E}c=\mathbf{E}\mathbf{i}.\mathbf{c}_1+\mathbf{E}\mathbf{j}.\mathbf{c}_2+\mathbf{E}\mathbf{k}.\mathbf{c}_3, \quad . \quad . \quad . \quad (97)$$

$$c'\mathbf{E}=\mathbf{i}.\mathbf{c}'_1\mathbf{E}+\mathbf{j}.\mathbf{c}'_2\mathbf{E}+\mathbf{k}.\mathbf{c}'_3\mathbf{E}. \quad . \quad . \quad (98)$$

These are identical vectors always. In the symmetrical case, the accents may be dropped, of course; then $\mathbf{E}\lambda=\lambda\mathbf{E}$. It will be seen that the above way of writing and working dyadics fits in precisely with all the previous notation employed in the vector algebra. The dots in (94) are merely separators, not signs of multiplication. When we put on a vector, before or behind, it unites with the vectors it is *not* separated from by dots; we therefore obtain the forms (97), (98), in agreement with the principles of notation described in the early part of this chapter.

We have already pointed out that $\mathbf{E}\lambda\mathbf{F}$, where λ is symmetrical, may be regarded as the scalar product of $\mathbf{E}$ and $\lambda\mathbf{F}$, or of $\mathbf{E}\lambda$ (the same as $\lambda\mathbf{E}$), and $\mathbf{F}$. The corresponding general property is the same; that is, c being general, $\mathbf{E}c\mathbf{F}$ is the scalar product of $\mathbf{E}c$ and $\mathbf{F}$, or of $\mathbf{E}$ and $c\mathbf{F}$. But $\mathbf{E}c$ is the same as $c'\mathbf{E}$, and $c\mathbf{F}$ the same as $\mathbf{F}c'$, so we have

$$\mathbf{E}c\mathbf{F}=c'\mathbf{E}\mathbf{F}=\mathbf{E}\mathbf{F}c'=\mathbf{F}c'\mathbf{E}=\mathbf{F}\mathbf{E}c. \quad . \quad . \quad (99).$$

The operator c must be united with one or other of the two vectors $\mathbf{E}$ and $\mathbf{F}$, but it is immaterial which it is, provided we always change to the conjugate properly, as exemplified.

The same applies when there are many linear operators. Let there be three, a, b, c. Then we have, to illustrate how the transformations are made,

$$c\mathbf{E}ab\mathbf{F}=\mathbf{E}c'ab\mathbf{F}=\mathbf{E}c'a\mathbf{F}b'=\mathbf{E}c'\mathbf{F}b'a', \quad . \quad (100)$$

and so on.

We may also introduce anywhere a new operator, accompanied, of course, by the reciprocal operator; thus

$$c\mathbf{E}a\mathbf{F}=c\mathbf{E}ab^{-1}b\mathbf{F}=c\mathbf{E}ab^{-1}\mathbf{F}b'=\&c. \quad . \quad (101)$$

The above will be sufficient to show the great power gained by the use of the operators, enabling one to do almost at sight algebraical work which would, in Cartesians, cover pages.

§ 170. The following little theorem, due to Hamilton, will serve to illustrate the working of vectors, as well as another purpose, which will appear later.

Let $\mathbf{m}$ and $\mathbf{n}$ be a pair of vectors, then their vector product $\mathrm{V}\mathbf{mn}$ is perpendicular to both, by our definition of a vector product. That is,

$$0=\mathbf{m}\mathrm{V}\mathbf{mn}, \qquad 0=\mathbf{n}\mathrm{V}\mathbf{mn}, \quad . \quad . \quad . \quad (102)$$

by our definition of a scalar product, and the parallelepipedal property. Now introduce cc^{-1} betwen the V's and the vectors preceding them in (102). Thus

$$0=\mathbf{m}cc^{-1}\mathrm{V}\mathbf{mn}, \qquad 0=\mathbf{n}cc^{-1}\mathrm{V}\mathbf{mn}. \quad . \quad (103)$$

These assert (and we cannot but believe it) that the vector $c^{-1}\mathrm{V}\mathbf{mn}$ is perpendicular to the vectors $\mathbf{m}c$ and $\mathbf{n}c$, or $c'\mathbf{m}$ and $c'\mathbf{n}$; it is, therefore, parallel to their vector product. The last statement is expressed by

$$xc^{-1}\mathrm{V}\mathbf{mn}=\mathrm{V}c'\mathbf{m}c'\mathbf{n}, \quad . \quad . \quad . \quad . \quad (104)$$

where x is an unknown (or so far undetermined) scalar. Or, operating on both sides by c,

$$x\mathrm{V}\mathbf{mn}=c\mathrm{V}c'\mathbf{m}c'\mathbf{n}. \quad . \quad . \quad . \quad . \quad (105)$$

To find the value of x, we have merely to multiply (105) by a third vector, say $\mathbf{l}$. For this gives

$$x\mathbf{l}\mathrm{V}\mathbf{mn}=\mathbf{l}c\mathrm{V}c'\mathbf{m}c'\mathbf{n}=c'\mathbf{l}\mathrm{V}c'\mathbf{m}c'\mathbf{n}, \quad . \quad (106)$$

which gives the value of x explicitly, namely,

$$x=\frac{c'\mathbf{l}\mathrm{V}c'\mathbf{m}c'\mathbf{n}}{\mathbf{l}\mathrm{V}\mathbf{mn}}, \quad . \quad . \quad . \quad . \quad . \quad (107)$$

to be used in (105), which, with x thus settled, is the statement of the little (but important) theorem. The quantity x appears to depend upon $\mathbf{l}$, $\mathbf{m}$, $\mathbf{n}$. These vectors, however, enter into both the numerator and denominator in such a way that they can be wholly eliminated from x. This may be seen by expanding the numerator and denominator. In fact, x is a pure constant, depending upon the operator c alone.

In the symmetrical case we may find its value by taking $\mathbf{l}$, $\mathbf{m}$, $\mathbf{n}$ to be $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$, and the latter to be the principal axes. Thus

$$c'\mathbf{l}=c\mathbf{i}=c_1\mathbf{i}, \qquad c'\mathbf{m}=c_2\mathbf{j}, \qquad c'\mathbf{n}=c_3\mathbf{k},$$

if c_1, c_2, c_3 are the principal scalar c's. So, by (107),

$$x=\frac{c_1\mathbf{i}\mathrm{V}c_2\mathbf{j}c_3\mathbf{k}}{\mathbf{i}\mathrm{V}\mathbf{jk}}=c_1c_2c_3, \quad . \quad . \quad . \quad (108)$$

the continued product of the principal c's.

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In the general case we may put, as we know,

$$c = \lambda + V\mathbf{a}.$$

Using this in (107), on the understanding that c_1, c_2, c_3 are the principals of λ now, we shall get, similarly,

$$x = c_1c_2c_3 + \mathbf{a}\lambda\mathbf{a}, \quad . \quad . \quad . \quad . \quad (109)$$

which it will be a useful exercise to verify.

Since c is any linear operator, (105) remains true when for c we substitute its conjugate c', producing

$$x'V\mathbf{mn} = c'Vc\mathbf{mc}\mathbf{n}, \quad . \quad . \quad . \quad . \quad (110)$$

where x' is got from the expression for x by changing c' to its conjugate c. But c and c' only differ in the changed sign of $\mathbf{a}$, as in (88), (89). On the other hand (109) contains $\mathbf{a}$ quadratically, so that a reversal of its sign makes no difference. Therefore, x' is the same as x, which might not have been anticipated at the beginning of the evaluation.

(To be continued.)

SOME ANOMALIES IN DYNAMO DESIGN.*

It is frequently stated that no one can design a dynamo who is not a trained engineer. If this be the case, dynamos must be in rather a backward state, for very few dynamos are nominally designed by engineers. On the other hand, an eminent and very successful dynamo maker has said that a "cow of average intelligence could design two bearings, and that is all the engineering there is in a dynamo." Probably the truth lies between these extremes. There is not much engineering construction in a dynamo, and in most cases the machine bears the name of this or that electrician, while all the engineering details are worked out by experienced draughtsmen, who get little or no credit for their work.

Some years ago the complaint was made that dynamos were mechanically bad. The armatures were mounted on wooden hubs, and the machines looked as if they had been made by an optician. Now we are going to the other extreme. In order to appear "a thoroughly mechanical piece of work," a dynamo is made with a ton or two of extra cast-iron, parts having stresses in pounds, but made heavy enough to stand pulls of many tons. The most serious forces in a dynamo are the magnetic pulls of the fields on the armature or on one another, but these receive very little attention. Few dynamos are designed to take these pulls fairly, and their value in pounds or tons is very seldom worked out. The air space in many dynamos decreases visibly when the field is excited. Still, these pulls are steady, and not intermittent, so little harm is done, though badly designed machines have come to grief from this cause. The most common method of making a dynamo into a "good solid piece of engineering" is to develop its bed-plate to an abnormal extent. But the only important stresses in a dynamo are internal; the motion is steady, and the other forces in the machine are insignificant. It is, therefore, unnecessary to mount the machine on an extensive substructure of hollow cast iron work. Many modern dynamos look as if their designers thought they would bend unless carefully secured to good solid foundations of rock by means of ample castings capable of withstanding the enormous stresses derived, presumably, from the belts or ropes. The illusion is generally entirely spoilt by hoisting the whole thing on to two little slides, so as to admit of tightening the belt. There are many odd sights in electric stations and installations, but few are stranger than a dynamo with a ponderous bed-plate mounted on foundation rails. If the machine is designed to be used on foundation rails the bed-plate might be omitted, and full provision made for the dynamo to rest on the foundation rails, but it should not look as if it were trying in vain to sit down upon a large area, but could not reach the ground. If a casting is needed to form the framework of the dynamo, it should be arranged as a frame, and not as a bed-plate, and it might be designed much in the same way as the entableture of a paddle-wheel engine.

Any good impression that might be made by the imposing amount of cast-iron in a modern dynamo is sadly weakened by the eyebolt with which an electrical engineer always crowns his work. The eyebolt suggests that the dynamo may break down at any instant, and can be whisked off—if such an expression can be used without disrespect to the bed-plate—and replaced by another at a moment's notice. The electrician's eyebolt is almost unique. Cylinder covers, piston rods, and other parts of marine engines have eyebolts; but they are inserted and taken out by hand when the vessel comes into port. Engineers do not provide eyebolts in other cases. The boilers of a steamer, for instance, are dropped in without difficulty, and an engine maker does not send out, say, a hundred-horse stationary engine all in one piece with an eyebolt, so that it can be lifted like a dynamo or a lady's parcel. In spite of its odd appearance, the eyebolt has some advantages. But the money spent in making it, and carefully polishing it all over—a most essential process it would seem—can hardly be saved in reduced cost of carriage due to ease of lifting in those cases where sufficiently powerful cranes are in use.

The windings, except in rare cases, are left exposed. Sometimes they are painted red. This is a survival of the days when opticians painted electrical apparatus with red sealing-wax varnish. They ought, of course, to be covered in. In America they are sometimes roped, but rope is a bad conductor of heat. Besides, a dynamo has already so much paper, cotton, vulcanised fibre, string, and other materials suggestive of postage-stamp edging and sealing-wax, that it is a pity to use rope when metal can be employed. After a few years' work most dynamos are started with oil. This is due to the design of the bearings not being thoroughly worked out. The drawing office designs a bearing, and the machine is sold, and nothing more is heard of it until the insulation breaks down, and it comes back to be re-wound; but even then nothing is attributed to the bearings. This is one of those cases—common enough in engineering—of want of touch between the makers and users of machinery.

* Abstract from an article in *Industries*.

BOOKS, &c., RECEIVED.

"The Practical Management of Dynamos and Motors." By Francis B. Crocker and Schuyler S. Wheeler, D.Sc. (London: E. and F. N. Spon.) 32 pages.

"Le Premier Réseau Français de Cables Sous-Marins." Par M. Ernest Vlasto. Extract from the *Proceedings* of La Société des Ingénieurs Civils de France. (Paris. 17 pp., with charts.)

"Street Railways: the Construction, Operation, and Maintenance." By C. B. Fairchild. (New York: Street Railway Publishing Company.) 434 pp. demy 4to.

"Domestic Electric Lighting: Treated from a Consumer's Point of View." By Ed. C. de Segundo. (London: Alabaster, Gatehouse and Co.) 115 pp. royal 16mo.

"Science and Practice of Lighting." By W. H. Y. Webber. (London: Walter King.) 100 pages, demy 8vo.

"Prospectus of the Grosvenor Museum Technical School." (Chester: G. R Griffith.)

"Die Akkumulatoren." By Johannes Zacharias (Jena: Hermann Costenoble.) 251 pp.

"Handbuch der Elektrotechnik." By Dr. Erasmus Kittler. Three vols. (Vol. I. Second Edition.) (Stuttgart: Ferdinand Enke.)

"The Water Waste of London." By W. G. Kent and H. H. Kent. (London: E. and F. N. Spon). 20 pp. demy 8vo. Price 3d.

"La Fabrique Nationale d'Armes de Guerre à Herstal et ses Installations Électriques." By L. Castermans. (Paris: C. Borrani.) 60 pp. royal 8vo.

"Calendar of the University College of North Wales." (Manchester: J. E. Cornish.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, October 21st.

ELECTRICAL TRADE SECTION.

5 p.m. Meeting at Botolph House, Eastcheap.

WEDNESDAY, October 26th.

INSTITUTION OF MECHANICAL ENGINEERS.

7:30 p.m. Papers to be read and discussed.

INSTITUTION OF MINING AND METALLURGY.

8 p.m. Presidential Address; after which, the following Papers will be discussed: (1) "Mining in the Malay Peninsula: A Field for Mechanical Appliances, Hydraulics, and Electrical Transmission of Power," by H. M. Becher; (2) "Auriferous Iron Sands and the Methods of Extracting Gold therefrom," by Lieut. W. Bassett.

FRIDAY, October 28th.

PHYSICAL SOCIETY.

5 p.m. Paper to be read: "The Determination of Critical Density, Critical Volume, and Boiling Points," by Dr. Young and Mr. Thomas, to be discussed together with the Paper on "The Laws of Molecular Force" by Mr. Sutherland, and "The Dimensions of Physical Quantities," by Mr. Williams.

OLD STUDENTS' ASSOCIATION.

7:30 p.m. Annual Dinner at the Holborn Restaurant.

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With "THE ELECTRICIAN" for October 28th will be issued a Supplement STEEL-PLATE PORTRAIT of the late CYRUS W. FIELD, Pioneer of Ocean Telegraphy.

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SUBTERRANEAN PARIS.

Electrical engineers are generally content to leave the gas industry alone, and to regard it as offering enough competition to keep things up to the mark, but not as a dangerous rival. The principals being fairly peaceable, strife was hardly to have been expected between the inanimate elements of their plant. No struggle could be more quiet and inoffensive than a match between two street lamps, to decide which of the two would give the better light—electric or gas. But we learn from the French journals that beneath the streets of Paris a subterranean warfare of a fierce, and indeed, madly suicidal, character has been going on for months, between the electric mains and the gas mains. More than once in this country gas has leaked out into the soil, and has wandered thence into electrical conduits, and, shocked to find itself in contact with its foe, has incontinently exploded. A paving stone or two has been lifted, and an iron cover raised. The spark which fired the gas has never been accounted for; some people, indeed, believe that sparks are quite common in electrical conduits, others speak obscurely of accumulated static discharges, or make random suggestions as to lightning flashes. As a matter of fact, any conduit does excellently well, and on the last occasion an explosion occurred in a telegraph junction box at Newcastle, and this, not even in election time. But in all these cases the gas mains came off scot free, and only indirect damage was done to the electric conductors.

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In Paris, on the other hand, we read that the gas pipes have been visited with a strange disease: they break out with a plague of pitted corrosion, become honeycombed with perforations, and are bathed in corrosive secretions. Nor are the electric mains uninjured, for we learn that the stoneware conduits or troughs containing the conductors become filled with "a mass of soda and potash salts, sometimes to the extent of several kilogrammes," and "the conductors themselves, especially the negative main, are so powerfully attacked that conductors having a cross sectional area of 40 sq. mm. (about No. 2 S.W.G., or 0·28 in diameter) have been ruptured."

On the whole the gas mains have had the worst of it, and the question at once rises, "Why in France only?" We have heard of a mysterious corrosion at the back of a gas meter, and the St. James's and Pall Mall Company were accused of the damage. Investigation, however, proved that the spark seen in a switch led some timid tinker—probably well acquainted with escapes of gas—to believe that there was a serious "escape of electricity." The official inquiry left the electric company without a stain on its character. It is, perhaps, not generally known that 90 per cent. of the gas mains in Paris are made of sheet iron, varying in thickness from one millimetre to four or five millimetres for pipes of one metre in diameter. The exact composition of these pipes we are unable to give. The ambiguity of the French language, so invaluable in diplomacy, and so amusing in drama, is annoying in metallurgy. About a fortnight ago we were puzzled over "*acier de moulage*," which might have meant cast steel had it not been apparently differentiated from "*fontes*." *Cuivre jaune* and *cuivre rouge* are also generally used with looseness, and often without the adjective. In "Le Gaz et ses Applications," a most interesting book, we find that these pipes are made of *tôle plombée*. This is not the recognised term for galvanised iron, and further, they are said to be coated with *une mince couche de plomb*. We are slow to believe that a lead covering can be so easily applied. However this may be, the surface is covered with bitumen very adherent to the metal. But experience seems to have shown, experience prior to the advent of electric lighting, that these pipes are subject to rapid oxidation, although, we read, this oxidation does not produce any disadvantageous effects, unless in exceptionally damp soils. With another defect, the "*oralisation*," which might be expected, we have nothing to do. It seems, then, from the account which will be found in another column, that when these stove-pipe mains run near to leaky electrical conductors they are subject to "*perforations*." The context shows that we are not always justified in translating this by "perforations," and we have for the most part used the word pitting instead—another example of the vagueness of French technical terms. Bad corrosion seems to have been found in cast-iron mains of reasonable thickness, but before any apprehensions need be felt about the gas pipes in our own streets it would be well to inquire into the extraordinary quantity of chlorine and sundry other reagents with which the soil of Paris seems to be impregnated. The salt used for melting snow may account for it, and a theory has indeed been put forward that this becomes electrolysed into metallic sodium, which, coming in contact with water, if there is room for water among all these chemicals, suffers spontaneous combustion.

We hope that our French friends will take the "minute precautions" which are thus found to be necessary, and set in order those "secondary mains which are laid with less care, the conductors being laid through stoneware without any insulators." It is the fashion only of alternate current men to lay insulated cables direct in the ground, in this country, and no such troubles need be feared from them. The proposed remedies are of some interest, and the subject ought to be considered in connection with the earthing of the middle main of three wire systems. So far as corrosion has gone in this country, and that is but a little way, the mains themselves alone have suffered and ample warning has been given. Damage to other pipes is as yet unknown, and surely there is plenty of opportunity for inspection. The observant Londoner knows almost as much of the subterranean arrangements as he does of the surface, so many are the opportunities for examining them when the streets are "up." The concluding observations in the article on which these remarks are founded ought, indeed, to spur Mr. Ferranti, his late partner, M. Patin, and other alternate-current men in France to show, in the phraseology of our French contemporary, some of "the general and convenient applications of which alternate currents are already susceptible."

REVIEWS.

Photométrie Industrielle. By A. Palaz. (Paris: Georges Carré.)

The art of photometry has been somewhat despised both in the laboratory and in commerce. No very accurate measurements can be made, hence they lose scientific interest, while commercial testing has tended to resolve itself into an effort on the part of the Gas Companies to persuade the authorities that the gas tested is of passable quality. Under these circumstances there was no object in increasing the sensitiveness of photometric measurements. This state of things, however, has been altered by the increasing competition between gas and electric lighting, and of late years great progress has been made in perfecting all light-measuring apparatus.

Perhaps the best known English book on photometry is that of Dibdin, and in Germany an excellent little book on "Electrotechnical Photometry" has been written by Krüss, but neither of these books covers so wide a range as the present work, which is a complete and readable treatise on the subject with which it deals. Although the author occasionally indulges in mathematical writing, the great part of the book is taken up with descriptions of apparatus and experiments, the discussion of results, and explanations of various matters, which, although of importance in commercial lighting, are not yet to be found in any other work on photometry. As most of the matter has previously appeared in technical periodicals, the contents have no claim to originality; but they form a valuable summary of the work which has been published on that part of optics connected with commercial lighting.

The volume is divided into six chapters. In the first, which is short and merely introductory, the fundamental terms are explained, and reference is made to the sensibility of the eye for different colours, and to the character of the rays emitted by various well-known sources of light. The chapter concludes with a theoretical discussion of the method of getting the mean spherical candle-power of a light from observations of its candle-power in different directions. This discussion might with advantage have been postponed till a later part of the book, as it is rather long, and is only applicable to the particular case of an arc light.

The second chapter is an exhaustive little treatise on photometers. It seems to be a carefully revised reprint of an excellent series of articles published by the author some time ago in the pages of *La Lumière Électrique*. It is illustrated, as the book is throughout, by diagrams which are both numerous and clear. Critical remarks about the photometers are occasionally made, but more could advantageously be added. Many instruments are described which are only occasionally used, the length of the description being no criterion of relative importance. The Bunsen screen, and the various modes of using it, are well described, and the theory of it is given at great length; but the Joly photometer, which is equally good, though not so well known, is dismissed very briefly, less space

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being devoted to it than to photometers of less importance. Other sections of the chapter are devoted to polarisation photometers, spectrophotometers, absorption and dispersion photometers, and to others of a more miscellaneous type. There is little to suggest in the way of additions to the list. Something might have been said about measurement by means of photography, and one or two of the photometers designed for astronomical purposes might have been alluded to. A more important omission is the absence of any reference to the important work of Captain Abney on colour photometry. The name of Fox-Talbot ought also to have been mentioned in connection with Napoli's photometer, described on page 53. In this instrument the light from one of the sources to be compared is cut off in a known proportion by means of a revolving shutter provided with an aperture whose area can be adjusted at will. This simple and valuable device was originally described by Fox-Talbot, and has been much used by Captain Abney in his researches. Some good photometers have of late years been designed for the measurement of illumination as distinct from candle-power. The first, we believe, was due to Weber, and the second to Mascart, but although Weber's instrument is described, no allusion is made to its use as an illumination photometer.

The third chapter deals with the vexed subject of light standards. The different forms of lamp which have been suggested are well illustrated with diagrams, some being drawn to scale and dimensioned, and the opinions of the various workers on light standards are quoted. Rather too much space is devoted to describing the absolute standard of Violle, considering the impracticable nature of the unit.

The fourth chapter is taken up with a description of the various accessory apparatus used in photometry, such as the mounting of lamps and the arrangement of benches; and the fifth chapter deals with the character of the light emitted by arc and glow lamps, the report of the Franklin Institute in 1881, and the experimental work on the efficiency and character of various electric lights, which has been carried out since that date in American and other laboratories. The work is well up to date, reference being made, for instance, to quite recent work by Prof. Nichols and Mr. Tesla. A short paragraph on the absorbing power of opal, and other diffusing globes, only exhibit the lack of information which prevails on this important matter.

The last chapter of the book is devoted to the distribution and measurement of illumination. This subject is an entirely new one in a text-book, although it has been written about in periodicals and in Papers read before learned societies. Illumination is the whole object of lighting, and it is strange that so little attention has been paid to it hitherto.

GEARING.

BY E. TREMLETT CARTER.

(*Continued from page 643.*)

Spur Gearing.

This, one of the oldest forms of gearing, is now very extensively used by electrical engineers for tractive and other motor work. Within the limits of strength of the teeth of which it is formed it is perfectly positive in its action, slipping being impossible except in those cases where the gear is not properly set. Spur gear does not, however, possess that property of so interlocking the paired parts as to prevent back running, which we saw was so useful a property of worm gear; the motion being reversible with unaltered efficiency, whatever the design of the teeth. This form of gear consists in a number of short teeth or cantilevers projecting at equal distances from the rims of two wheels, the wheels running on parallel axes at such a distance apart that the teeth of one wheel nearly reach the bottom of the spaces between the teeth of the other. It is considered inadvisable that the teeth should actually "bottom," and there is no doubt that in certain classes of work, such as traction, a clearance is necessary. The materials of which spur gear has at different times been made are cast steel, phosphor bronze, gun-metal, wrought-iron, cast-iron, wood, and vulcanised fibre; and most of these have been used for electrical work. Cast iron is a common material on account of its cheapness and of the ease with which wheels can be manufactured; but it is a brittle and unreliable material, especially where the gear is liable to jolts or shocks, and the teeth when simply cast are rough and wasteful of power. Trimmed cast-iron teeth are used with advantage in heavy slow-moving stationary gear. Cast-steel possesses almost all the desirable qualities for spur wheels; it is strong, capable of a high degree of hardness, and fairly tough; but when used in gear with the same material it has a high coefficient of friction. Gun-metal and phosphor bronze are frequently used in pinions, *i.e*, in the smaller of two wheels in gear, the larger wheel being of cast steel, this combination having a high efficiency on account of the low coefficient of friction. Wood and vulcanised fibre recommend themselves solely on account of the reduced noise with which gear of these materials will run; but, as far as electrical work is concerned, appear to have been signal failures. For some time the latter material was tried on the electric tramcars at Croydon, but was found not to be capable of standing the severe shearing action when the brakes were suddenly applied. Wrought-iron, on account of its toughness, has been tried for gear running at speeds above the usual limit; and, while the teeth of this material do not so readily strip from the wheel, the want of hardness results in rapid scraping away of the surfaces of the teeth, an effect which even case-hardening is

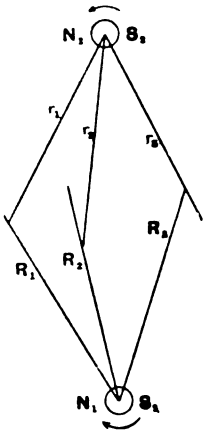

FIG. 20.

incapable of seriously reducing. In some cases the spur-wheel is cast or wrought in one piece, but in the case of the weaker materials the teeth are more frequently morticed into a frame-wheel of some stronger metal.

It would be impracticable, within the limits of such a series of articles as the present, to enter into the complicated questions of the design and construction of spur gear, the theory of which involves an elaborate mathematical treatment. It is intended to remark only upon those practical questions which affect the use of this gear by electrical engineers. Usually spur gear is employed to effect reduction of speed from a fast-running electromotor. It will, of course, be desirable that the motor, which is running at a constant rate of revolution, should produce as constant a speed in the ultimate shaft it has to drive. The gear must, therefore, act as if two smooth wheels in contact were driving one another without slipping. Such imaginary wheels conceived to be turning with the driving and the driven shafts are called the *pitch circles*. Formerly spur gearing was cast in straight, rectangular or cylindrical teeth; but it will be seen, by reference to Fig. 20, that such teeth would not produce the even motion just described. A shaft, S_1, is turning at N_1 revolutions per minute, and is driving the shaft S_2. The motion is communicated by means of a straight tooth, R, represented by a radius of the pitch circle on S_1, and by another straight tooth, r, into which it gears. Now it will be seen that when these teeth first come into gear, since the radii to the point of contact are equal, the shaft S_2 will be turned at the same rate as the shaft S_1. Not so a moment later, when the teeth are in the position shown by R_2 and r_2; for then the tooth R is at a smaller radius than r, so that the second shaft

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will be turned slower than the driving shaft. And in the third position it will be seen that the second shaft will be turned quicker than the driving shaft. This crude mode of explanation may serve to emphasise the fact that unless the teeth are constructed of the proper shape there will not be a tendency to constant velocity ratio between the two shafts. Now the result of this action is to cause the driven tooth to run out of gear, and to be propelled forward till it comes into violent collision with the next tooth. For it is clear that owing to its inertia the driven shaft will resist the sudden changes in speed which the driver tends to cause; and, moving on or pressing back, will set up strains in the gearing or cause noisy collisions between the teeth.

In choosing the proportions and number of the teeth and the wheels, engineers have frequently made the assumption, correct enough according to pure theory, that two or more pairs of teeth will be in gear at the same instant. If this were practically the case, and if the gear could be relied on to retain this condition, the load would be divided between the sets of teeth in gear, so that the strength of each tooth might be designed accordingly. Now this assumption implies absolutely perfect workmanship, and that the wheels should be so accurately set and so rigidly held in place that there could be no change in the parallelism or distance between the shafts. It also implies an equal rate of wearing in every tooth. None of these conditions are realised in practice, and the probable departure from them is sufficient to make it unsafe to design teeth on the supposition that several pairs will take the load, unless a very high factor of safety is taken. It would probably be best to take a reasonably high factor of safety, and to proceed on the assumption that each pair will take the whole load during the interval that it traverses the arc of contact. Of course, having designed the teeth to have this strength, there will be no objection to their being so set that, under normal conditions of running, there will be two or three pairs in gear at any instant. These considerations affect the design of the thickness, pitch, clearance, width, and length of the teeth.

The thrust or effort on the tooth due to transmitted power is—

$$F = \frac{550\ H.P.}{v},$$

where F is the thrust in lbs., H.P. is the maximum power transmitted, and v is the velocity in feet per second at the pitch circle. This also measures the shearing stress at any point in the tooth below the point of application of the effort; but there are, in most teeth and those where the length is not inconsiderable as compared with the thickness, other stresses, arising from the bending moment of F about the root of the tooth. This bending action is the same as in a cantilever loaded at one point, the resistance to such a load being proportional to the square of the thickness, to the width, and inversely to the length between the load and the root or support. The longer the teeth, then, the greater the stresses upon the material. It will be observed that the higher the velocity at which the teeth are run on the pitch circles the less the load; but it is inefficient to run them at high speeds, because at high speeds there is more grinding or scraping between the surfaces, and greater loss of power. There is also, at high speeds, excessive wear; and the inertia being greater, there is more chattering or "back lash" between the teeth in gear. In traction work the maximum thrust, F, does not occur under the normal conditions of running, nor even when the maximum H.P. is being transmitted; for the ratio of H.P. to the speed v becomes a maximum the instant after starting commences. The starting effort is required to overcome forces which do not come into action during the normal running, and the teeth must be designed to stand this maximum thrust. In a previous communication ("On Traction," *The Electrician*, May 20, 1892) the author has shown how this maximum tractive force may be calculated. From this the maximum value of F at any point in the gearing may be obtained, for it will only be necessary to multiply the tractive force thus found by the ratio of the velocity of the car wheel rims to the velocity of the part of the gear under consideration, adding 5 or 6 per cent. to allow for gear friction.

In traction work, where considerable departure from parallelism occurs, the strength of the tooth must be designed independently of the width which the wheels will have; for it will sometimes happen that the thrust will act entirely on one corner or end of the tooth. Owing to this skewing tendency in some gears it may happen that a wide wheel is weaker than a narrow one, for with the former there is a wrench on the teeth when skewing takes place which is not found so much in the latter. It is actual experience in many instances that where teeth have stripped, and wheel after wheel has failed, the substitution of a narrower wheel has remedied the defect. For stationary work the width of gear wheels is usually about four to six times the pitch, but for traction work it would be safer to employ narrower wheels. The thickness, then, should be such that a tooth will stand the entire maximum thrust, F, at its corner, a sufficient factor of safety being taken on account of the impulsive nature of this load. A factor of 10 is usually taken for this purpose. A rule in use among English engineers gives the thickness of a tooth as:—

$$t = \sqrt{\left(\frac{30\ F}{f}\right)};$$

where f is the ultimate strength of the material in pounds per square inch, and t is the thickness in inches. A rule commonly adopted in other countries is one which is in a convenient form for general use, and is as follows, when reduced to English measures:—

$$t = k\sqrt{\frac{H.P.}{V}};$$

where H.P. is the power transmitted, V is the velocity at the pitch line in feet per minute, and k is a constant. The values of k are:—

Cast iron ..	51·4
Bronze	64·1
Hard wood	71·1

The amount of clearance which is allowed between a tooth on one wheel and the next tooth on the other wheel with which it is not in contact varies with the finish of the surfaces and the nature of the work to be done. In stationary work it is usually one-tenth of the pitch for cast wheels not trimmed, or for wheels of different materials, and one-fifteenth of the pitch for well-finished trimmed teeth. Where there is much tendency to shifting of the relative position of the shafts, however, a greater clearance should be permitted to avoid wrenching the teeth from the wheels. The pitch of the teeth will, of course, be equal to this clearance plus twice their thickness. Having determined thus much, the arc of contact and the length of the teeth may be finally decided upon. The amount of the arc of contact, that is of the arc through the geared teeth will pass in contact, depends on the velocity ratio of the wheels. If the wheels are running at very nearly the same speed, or if the ratio of their speeds does not exceed 2, the arc may be equal to about twice the pitch of the teeth; whereas, if the velocity ratio exceeds this, the angular motions of the geared teeth being so different, it will be impossible with teeth of reasonable and safe length to keep them in gear through as long an arc. In general, the length of the arc will diminish as the velocity ratio increases, the length of tooth being constant. Having determined the arc of contact at which it will be safe to run the teeth, the length of tooth may be set off. It must be remembered that long teeth are less liable to trip, *i.e.*, to jump out of gear, but are more liable to strip, and waste more power than short ones. Short teeth also hold the lubrication better than long ones, and run with less grinding and less "drop" on to one another. The usual practice is to make the tooth from two-thirds to three-quarters of the pitch in length; but it seems probable that much more satisfaction in traction work could be obtained with very much shorter teeth. It is likely that the best length for this class of work is that which is only a small fraction of an inch in excess of the length required to prevent tripping. Short teeth, narrow teeth, and fairly thick teeth seem to be the best adapted to silent, smooth, efficient, and long running in tractive work.

Two systems of reduction from that high speed at which the electromotor must run to that low speed at which it will be necessary to run the car axle have been employed, namely, the

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double and the single-reduction gear. The former is the older of the two, and is in some respects superior to the other. Where it is necessary to gear from a very high speed, such as that of low-power motors, to a very low speed, such as that of the axles of town tramcars, the velocity ratio is such that single reduction involves unsatisfactory pairing between the teeth. In double reduction the velocity ratio is divided into two nearly equal factors by the interposition of a countershaft. Fig. 21 shows the double reduction gear used on the Frankfort-Offenbach tramcars. The armature shaft, running at about 550 revolutions per minute, normal speed, carries a gun-metal pinion cast with 17 teeth. This pinion gears into a cast-steel wheel, having 56 teeth, keyed to a countershaft, which thus makes about 167 revolutions; and on the countershaft there is another gun-metal pinion having 26 teeth, gearing into a 52-tooth cast-steel wheel on the axle of the car. The ultimate velocity ratio is about 6·6, and the normal speed of the car axle is about 83·5 revolutions. In this particular case the teeth do not appear to have been very carefully trimmed, for the depreciation is high. The pinions wear out in about a month, and the steel teeth last only about ten months. In Philadelphia electric cars have been running with unrenewed wheels for a very much longer time, the teeth standing a service of several hundred miles without a hitch and with little wear. The pinions in this case are of phosphor bronze, but the wheels are of the same material as at Frankfort; the teeth in each wheel were carefully trimmed and

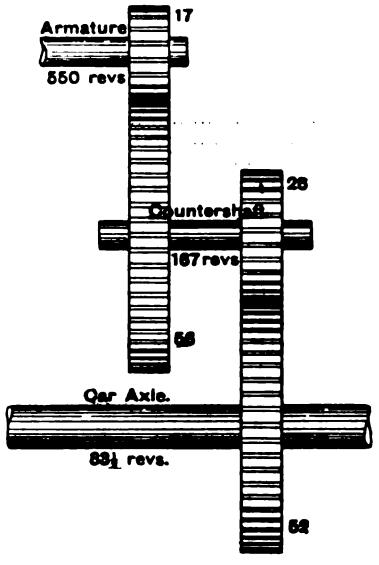

Fig. 21.

protected from road dirt. Only single reduction is effected at Philadelphia, but the velocity ratio is not so high as at Frankfort. Single reduction is suited to those cases where the velocity ratio is not greater than 2½; but beyond this figure the wheels become inconveniently large and the teeth do not properly pair. Stationary gears, such as those for coupling electromotors to pumps or cranes, are sometimes provided with a number of separate wooden teeth or *cogs*, which are fixed into a frame wheel, and easily renewed. This form of gear is also used at some water-power electric light stations. The cogs are cut and trimmed separately, and are tenoned into the frame wheel by means of wooden wedges or wrought-iron pins. Hornbeam, a white, very compact, hard, and tough British timber, capable of a very high polish, is largely used for these teeth; but Scotch beech is gradually replacing this material on account of its superior durability. Timber for this work requires to be exceptionally tough, and none but that grown on the hardest subsoils and seasoned for several years will stand the stresses on spur or bevel cog wheels.

[*Erratum.*—By an error, for which the author was in no way responsible, a three-thread worm was illustrated in Fig. 17 of his last article, instead of a one-thread worm as described. —Ed. *E.*]

(To be continued.)

A KEY TO ALL MAGNETISM.*

BY S. EVERSHED.

Given a fascinating field for research, the resources of an American laboratory, an experimenter with that faculty of patient plodding work characteristic of the Teutonic mind, and we have all the conditions for the production of a monograph almost as exhaustive (and exhausting) as Mr. Casaubon's "Key to all Mythologies." The Rev. Edward Casaubon died, we remember, before he completed his labours, leaving a widow, a mass of notes, and a "synoptical tabulation for the use of Mrs. Casaubon" behind him. Mr. Charles P. Steinmetz is wiser and more considerate of his executors; he publishes as he goes, and we have before us Part II. of his research "On the Law of Hysteresis," in the form of a Paper of some 110 octavo pages, read at the sixty-seventh meeting of the American Institute of Electrical Engineers. There are giants in America, but surely the Institute made more than one bite at such a Paper!

Setting aside its general diffuseness and somewhat inordinate length, this communication contains a large number of interesting and valuable results of a qualitative kind. In a former Paper Mr. Steinmetz had shown that for various samples of iron and steel the energy converted into heat during a complete cyclic change of induction followed the empirical law,

$$\text{energy wasted} = \eta B^{1.6} \text{ ergs},$$

and in the first chapter of the present contribution he carries his investigation many steps further by showing that this law is approximately true, not only for almost every conceivable

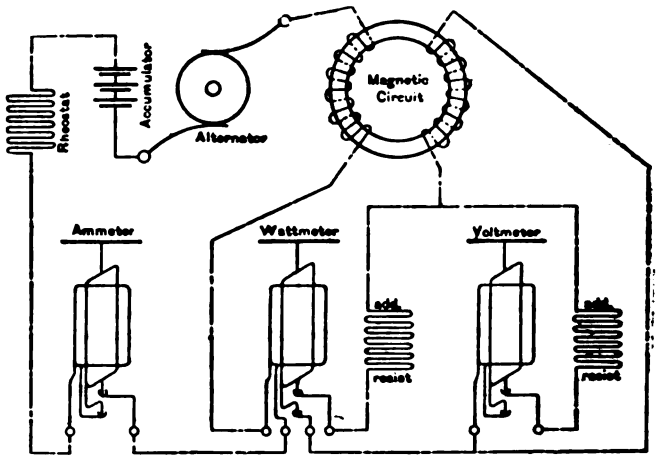

Fig. 1.

kind of magnetic material, but for cycles taken at any part of the B H curve, whether symmetrical about the origin or not.

This last result was obtained by maintaining a source of constant of E.M.F. in the magnetising circuit in addition to the periodic E.M.F. of an alternator, the power wasted being measured by a wattmeter and the induction by a voltmeter in the usual manner. Mr. Steinmetz obviated the need for corrections for C^2R in the exciting coil by coupling the pressure coil of the wattmeter to an independent coil wound along with the exciting coil. The arrangement will be clearly understood by reference to Fig. 1, which we reproduce from the Paper. These tests were made at frequencies varying from 67 to 170 periods per second. A good example of the closeness with which the 1·6th power law is followed is shown in Fig. 2, where the full line represents the empirical law; the points X are observations of loss with alternate currents only, while those marked ⊙ are observed values of loss when an alternate current is superposed on a direct current; the steady induction produced by the latter is marked in "kilolines" opposite each point. This figure contains in itself ample justification for the statement made by the author that

* "On the Law of Hysteresis (Part II.), and other Phenomena of the Magnetic Circuit." By Charles Proteus Steinmetz. A Paper read at the sixty-seventh meeting of the American Institute of Electrical Engineers, September 27, 1892.

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"the energy dissipated by hysteresis depends only upon the *difference* of the limiting values of magnetic induction between which the magnetic cycle is performed, but not on their absolute values; so that the energy dissipated by hysteresis is the same as long as the amplitude of the magnetic cycle is the same, no matter whether the cycle is performed for instance between the values of magnetisation.

$$B_1 = +\ 4000 \text{ to } B_2 = -4000,$$
$$\text{or } B_1 = +\ 6000 \text{ to } B_2 = -2000,$$
$$\text{or } B_1 = +\ 8000 \text{ to } B_2 = \pm\ 0,$$
$$\text{or } B_1 = +14000 \text{ to } B_2 = +6000.$$

In either case the hysteretic loss is the same since the magnetic variation is the same, viz.: $B_1 - B_2 = 8000$; hence the general form of the empirical law is

$$\text{Hysteretic loss per cycle} = \eta \left(\frac{B_1 - B_2}{2}\right)^{1.6} \text{ ergs.}$$

In Chapter II. our author returns to magnetometer work and devotes a large portion of the 40 pages to the description of tests made on some 60 or 70 samples of magnetic substances ranging from "Norway" iron to amalgam of iron. A number of valuable notes on these various materials are scattered at random through these pages; for example, Mr. Steinmetz finds that Mitis metal is for all practical purposes magnetically "identical with ordinary good wrought iron;" again, a sample of very soft annealed cast steel is "far superior to ordinary good wrought iron, and almost approaches 'Norway' iron."

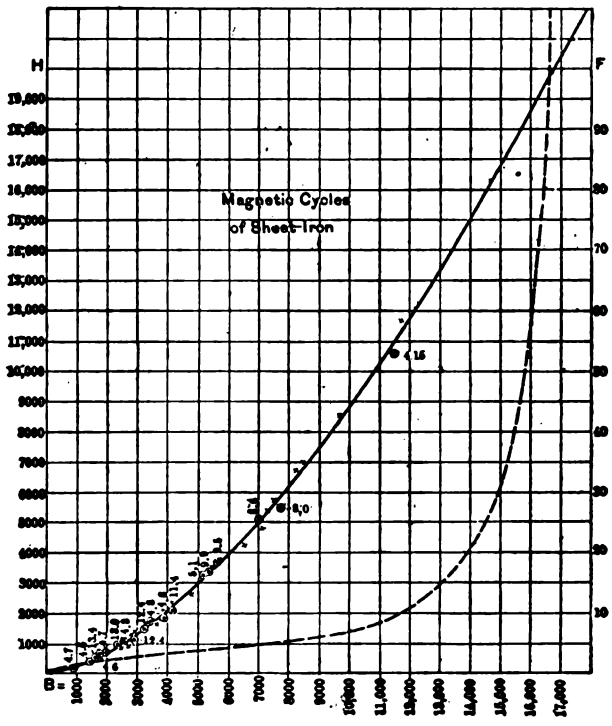

FIG. 2.

What this really means is, that its permeability is very little short of that found for "Norway" iron, while its hysteresis loss is some 40 per cent. larger—by no means an inordinate amount. We may note that cast steel of this quality is not unknown in England, and is being introduced to some extent in dynamo and motor building, in cases where somewhat complex pole pieces and frames are required. Its mechanical strength and high permeability leave little to be desired.

Perhaps the most interesting material included in these tests is the amalgam of iron obtained by electrolysing sulphate of iron with a mercury cathode. Mr. Steinmetz appears to have met with some little difficulty here. The present writer, who made some experiments on the magnetic properties of iron amalgam in 1886, found no difficulty in preparing it as rapidly as electrolytic copper, but the iron sulphate solution must be maintained as dense as possible by keeping it at about 100°C., otherwise very little iron is deposited. From this hot solution a bright deposit of pure metallic iron is readily obtained, and it is noteworthy that such iron has a larger coercive force than the best charcoal iron. The results given by Mr. Steinmetz for iron amalgam are in close agreement with those obtained by the present writer, and show a large coercive force and exceedingly small permeability. One would have expected a very small coercive force in a solution of iron in mercury, but the amalgam is, apparently, a definite crystalline alloy dissolved in more or less mecury. This chapter concludes with the tests of magnetite (loadstone), nickel, and cobalt, in the middle of which the author sandwiches a remark to the effect that "Ewing's values for hysteresis loss are the lowest ever observed on iron so far as I know." So far as we know also; in common with every designer of magnetic apparatus—from transformers to ammeters—we wish they were not quite so unique. The present writer has never found iron less than 20 per cent. worse than Ewing's "soft iron," and many samples are 40 or 50 per cent., and one sample with at least 90 per cent. greater hysteresis loss is on record.

Chapter III. is headed "Results," and the cream of them is contained in Table XLVII., which we reproduce here. In this table, as, indeed, throughout the whole Paper, Mr. Steinmetz is not content with recording the results of the tests, but continually compares them with the law of the 1·6th power for hysteresis loss, and Frölich's formula in new clothes for the relation of what the author calls metallic induction and magnetic force. Metallic induction is only another name for $4\pi I$, and is denoted in the Paper and in Table XLVII. by L. Magnetising force is measured in ampere turns per cm. (or per inch), and is denoted by F, then Frölich's formula is

$$L = \frac{F}{a + \sigma F},$$

where a is the coefficient of magnetic hardness,

σ " " " saturation,

when F is infinite L becomes $1/\sigma$, and this value is inserted in the table under L_∞. F_0 is the value of a/σ, and is evidently the value of F corresponding to $\frac{1}{2} L_\infty$. Yet another symbol is rampant in the Paper, namely, ρ—the "metallic magnetic reluctivity" or ratio $\frac{F}{L}$ and our author's pet law is contained in the statement that "beyond a certain minimum value of F, the reluctivity

$$\frac{F}{L} = \rho = a + \sigma F = \frac{F_0 + F}{L_\infty},$$

only another way of writing Frölich's formula. The hysteresis law is here given in slightly altered form—metallic induction being properly substituted for B—and we have the hysteresis loss

$$H = \eta \left(\frac{L_1 - L_2}{2}\right)^{1.6} = H_\infty \left(\frac{L_1 - L_2}{2L_\infty}\right)^{1.6}$$

where H_∞ is "the maximum value of hysteretic dissipation of energy for absolute saturation," whatever that may mean.

Mr. Steinmetz finds that these two fundamental empirical laws "hold good for all kinds of wrought and cast-iron and steel, for nickel and magnetite and most likely for amalgam of iron, hence apparently for all magnetisable materials."

We are not quite sure whether Mr. Steinmetz intends Table XLVII. to be referred to by the dynamo builder as a complete specification of every kind of iron. To our mind its chief use and interest lie in the widely differing values of a, σ and η, which—whatever be the precise meaning attached to them—clearly indicate the necessity for systematic testing of iron by every manufacturer of magnetic apparatus, in which the permeability, coercive force and hysteresis are of importance.

Better than a cloud of formulæ, more convincing than a volume of empirical mathematics, is the series of characteristic curves given in Fig. 3 (Fig. 17 of the Paper), and we give them here in the faith that they are drawn from experimental results, and not from Frölich formulæ. These curves are plotted in ampere turns per centimetre and "metallic induction"—or $4\pi I$.

The remainder of this chapter is occupied with an attempt to condense the previous results into tables giving average

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values for the magnetic "constants" of the different classes of magnetic materials in common use. A glance at Table XLVII. would have been sufficient to deter any one but the author from engaging in such fruitless warfare with Nature's irresponsible lawlessness. But Mr. Steinmetz clings to Frölich throughout, and appends to each table of magnetic properties the value of the "absolute saturation" of the substance, on the assumption that Nature behaves with a due sense of decorum; thus we find the absolute saturation of "average wrought and sheet iron" given at 18,200; while that for average cast iron is calculated to be 10,500. Of course, wrought and cast iron ought to be satisfied with that, but they are not. We believe Prof. Ewing has carried the first up to 45,000, and cast iron to 16,000. The present writer has carried wrought iron as far as 23,000, and cast iron to 14,500, and our author deplores this immoral state of things in the following paragraph:—

"With regard to cast iron, I must remark, however, that some tests of Ewing and others show magnetisations as high as L = 16,000, while I was never able to reach much beyond L = 10,000. It must be assumed, therefore, that either the linear law of magnetic reluctivity, $\rho = a + \sigma F$ ceases to hold for higher magnetisation than I was able to reach—*which is not likely, however*—or we must assume that there exist kinds of cast iron far superior to all the samples I ever came across, and if so, then very great improvements are possible in the manufacture of cast iron for magnetic purposes."

Could infatuation go further? What can be done with a man who prefers to accuse American founders of casting bad iron rather than abandon a more or less clumsy empirical formula—which it is ridiculous to call a law—and which was only made to fit the facts as far as they were known. Is it possible that Mr. Steinmetz is unable to distinguish between a physical law and that miserable abortion an empirical law? Mr. Steinmetz warns ironfounders "to keep manganese out of cast iron, since manganese is known to be the enemy of all the magnetic properties." May we warn him to keep empirical formulæ out of his researches since empirics are known to be the enemy of scientific progress?

After this we have a chapter headed "Heterogeneous Materials." It is crowded with F and L and ρ and σ, of course, but the really valuable results are given as curves, in most of which actual observations are plotted. By the way, one of the heterogeneous materials is an air gap, and we are cautioned quite seriously not to take the magnetic resistance between two parallel pole faces as equal to the ratio length/area. Have Dr. Hopkinson and Prof. George Forbes no readers in America? One interesting result given in this chapter relates to a tube full of iron filings, of which the hysteresis loss was larger than could be accounted for by molecular friction, being, in fact, at least four times greater than the value for the worst sheet iron tested by Mr. Steinmetz, and he concludes that molar friction of the filings themselves accounts for some of this increased loss. When the filings were solidified into a more or less rigid mass by saturating them with paraffin wax the hysteresis loss was reduced by nearly 50 per cent.

The last chapter contains "Conclusions and Fallacies"—such fallacies, we presume, as are omitted in the earlier part of the Paper. The author believes "that the best chance to arrive at a fuller understanding of the phenomena of magnetism we shall have whenstarting in the research from the correspondence H—L. (Hysteresis loss and metallic induction.) However, this law of the 1·6th power I believe is not a *differential* law like, for instance, the quadratic law of gravitation, but an *integral* law like the law of *probability*, with which it seems to be connected in some way." Perhaps they are, but possibly the author is just a little out of his depth here; at all events, we are.

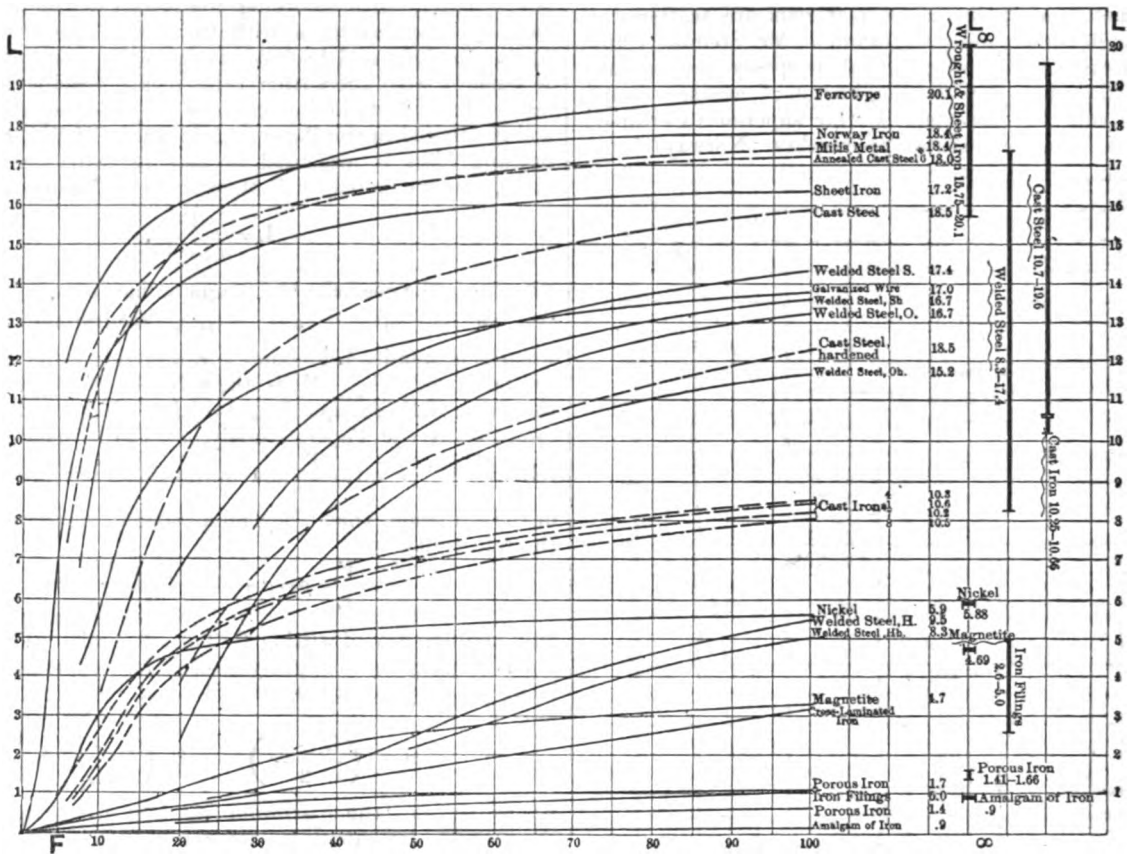

FIG. 3.

One of the fallacies attacked has reference to Ewing's magnetic model: "Ewing makes an assumption which is in contradiction to all our present knowledge of molecular physics. All the facts of the kinetic theory of gases, of thermodynamics, &c., carry to the conclusion that the *dimensions* of molecules are *infinitely* small compared with their *distances*. But Ewing supposes the distance of the centres of molecular magnets is not much greater than their length. . . ." Truly a most perfidious monster this Ewing. It seems sufficient to point out to our author first, that solid iron is *not* a gas; secondly,

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that Ewing only imagines a magnetic molecule—a particle, if you like—being led thereto by the behaviour of a bunch of real little magnets. In short, the Ewing model is only an analogue of a magnetic substance, and is naturally suggestive of the real structure of such substances. It is only by grasping at such gross materialisations of physical phenomena that our spiritual eyes can catch glimpses of that "Reality behind Phenomena" which must ever be the goal of scientific research.

Table XLVII.

Material.	Centimetre Measure.						Inch Measure.						Cm. Measure.	Inch Measure.
	a	σ	η	L_∞	F_0	H_∞	a^1	σ^1	η^1	L_∞^1	F_0^1	H_∞^1	$\gamma \times 10^6$	$\gamma^1 \times 10^6$
Wrought-Iron, Norway Iron	0·166	0·00535	0·002275	18·40	3·05	15·17	0·065	0·0084	0·00189	119·	7·8	248	14·4	12·0
„ Ordinary Wrought-Iron	0·20	0·05547	0·003260	18·03	3·61	21·09	0·079	0·0086	0·00271	116·	9·2	345	20·6	17·1
Sheet-Iron; thickness, $\delta = 0{\cdot}042$ cm.	0·275	0·068	0·00350	17·24	4·74	21·01	0·109	0·0090	0·00291	111·	12·1	345	22·1	18·4
„ „ 0·026 „	0·275	0·0507	...	19·7	5·42	...	0·109	0·0079	...	127·	13·8	...	...	...
„ „ 0·038 „	0·290	0·0561	...	17·8	5·17	...	0·114	0·0087	...	115·	13·1	...	...	...
„ „ 0·071 „	0·30	0·0522	...	19·2	5·75	...	0·118	0·0082	...	122·	14·6	...	...	...
„ „ 0·071 „	0·35	0·0542	...	18·5	6·46	...	0·138	0·0084	...	119·	16·4	...	...	..
„ „ 0·015 „ Ferrotype, Commercial	0·450	0·04975	0·00548	20·10	9·05	42·07	0·177	0·0077	0·00455	130·	23·0	690	34·6	28·7
Sheet-Iron; thickness, $\delta = 0{\cdot}014$ cm. Ferrotype, Annealed	0·337	0·04975	0·00458	20·10	6·77	35·16	0·133	0·0077	0·00380	130·	17·2	574	28·9	24·0
Sheet-Iron; thickness, $\delta = 0{\cdot}027$ cm. Tin-Plate	0·192	0·05464	0·002863	18·30	3·51	18·92	0·076	0·0085	0·00237	118·	8·9	310	18·1	15·0
Sheet-Iron; thickness, $\delta = 0{\cdot}038$ cm. Tin-Plate	0·321	0·05315	0·004255	18·81	6·04	29·37	0·127	0·0082	0·00353	122·	15·4	480	26·8	22·3
Very Soft Iron-Wire (Ewing)	0·20	0·0635	0·002	15·75	3·15	10·61	0·079	0·0096	0·00166	104·	8·0	174	12·6	10·5
Cast-Iron No. 1	2·40	0·0940	0·01300	10·66	25·5	36·18	0·95	0·0145	0·0108	69·	65·	592	82·0	68·
„ „ 2	2·43	0·0943	0·01317	10·60	25·8	36·26	0·96	0·0146	0·0109	69·	66·	594	83·0	69·
„ „ 3	2·76	0·0954	0·01577	10·48	29·0	42·70	1·09	0·0148	0·0131	68·	74·	700	99·5	82·
„ „ 4	2·05	0·09725	0·01132	10·28	21·1	29·72	0·81	0·0151	0·0094	66·	54·	486	71·4	59·
„ „ 5	2·34	0·0950	0·01267	10·52	24·7	34·56	0·93	0·0147	0·0105	68·	63·	566	79·9	66·
„ „ 6	2·07	0·0972	0·01220	10·29	21·3	32·08	0·82	0·0150	0·0102	67·	54·	526	77·0	64·
„ „ 7 (½% Aluminium)	2·37	0·0976	0·01365	10·25	24·3	35·77	0·94	0·0151	0·0114	66·	62·	584	86·1	71·
„ „ 8 (½% „	2·92	0·0948	0·01459	10·55	30·8	39·94	1·15	0·0147	0·0121	68·	78·	655	92·1	76·
Cast-Steel, Hardened	2·7	0·054	0·02792	18·5	50·0	187·7	1·07	0·0084	0·0232	119·	127·	3070	176·0	146·
„ Annealed	0·88	0·054	0·00848	18·5	16·30	57·00	0·347	0·0084	0·0070	119·	41·4	935	53·5	44·
„	2·00	0·0913	0·012	11·0	21·9	35·11	0·79	0·0141	0·010	71·	55·7	573	75·7	63·
„	0·82	0·0521	...	19·2	15·74	...	0·323	0·0081	...	124·	40·0	...	...	...
„	0·74	0·0509	...	19·6	14·54	...	0·292	0·0079	...	127·	37·0	...	...	...
„	0·76	0·0534	...	18·7	14·23	...	0·299	0·0082	...	122·	36·2	..	...	...
„	1·26	0·0931	...	10·7	13·64	...	0·495	0·0144	...	69·	34·7	...	...	..
„ (Average of 5 samples)	0·736	0·0568	0·009	17·6	12·96	55·85	0·290	0·0088	0·0075	114·	33·0	912	56·8	47·
„	0·68	0·0587	...	17·0	11·58	...	0·268	0·0091	...	110·	29·5	...	...	...
„	0·545	0·0575	...	17·4	9·48	...	0·215	0·0089	...	112·	23·0	...	...	...
„	0·44	0·0553	...	18·1	7·96	...	0·173	0·0086	...	116·	20·2	...	...	...
„ (Average of 5 Samples)	0·35	0·0535	0·005	18·7	6·54	34·19	0·138	0·0083	0·0041	121·	16·6	560	31·6	26·
„	0·344	0·0543	...	18·4	6·34	...	0·136	0·0084	.	119·	16·1	...	...	...
„	0·430	0·0700	...	14·3	6·14	..	0·170	0·0108	...	93·	15·6	...	...	...
„	0·300	0·0521	...	19·2	5·76	...	0·118	0·0070	...	127·	14·6	...	...	...
„	0·300	0·0543	...	18·4	5·52	...	0·118	0·0084	...	119·	14·0	.	...	...
„	0·308	0·0565	...	17·7	5·45	...	0·121	0·0087	..	115·	13·8	...	...	...
„ No. 5	0·260	0·05511	0·004573	18·15	4·72	29·82	0.103	0.0085	0·00380	118·	12·0	480	28·9	24·0
„ No. 6	0·232	0·05677	0·003181	17·95	4·16	20·38	0·092	0·0086	0·00264	116·	10·6	334	20·1	16·7
Mitis Metal	0·300	0·05444	0·004281	18·37	5·51	28·46	0·118	0·0084	0·00355	119·	14·0	466	27·0	22·4
Galvanised Wire	0·67	0·066	0·00349	15·15	10·15	17·03	0·264	0·0102	0·00290	98·	25·7	280	22·0	18·3
Welded Steel, Tool Steel *Hh*	8·0	0·121	0·0748	8·28	66·1	138·9	3·15	0·0187	0·0620	54·	168·	2280	472·	392·
„ „ *H*	7·8	0·105	0·0613	9·53	74·3	142·6	3·08	0·0162	0·0508	62·	188·	2340	387·	322·
„ „ *Oh*	1·9	0·066	0·0267	15·16	28·8	130·5	0·75	0·0102	0·0222	98·	73·	2140	168·	140·
„ „ *O*	1·54	0·060	0·0270	16·70	25·7	154·1	0·61	0·0093	0·0224	108·	65·	2530	170·	141·
„ „ *Sh*	1·33	0·060	0·0190	16·70	22·2	108·4	0·53	0·0093	0·0158	108·	57·	1780	120·	100·
„ „ *S*	1·22	0·0575	0·0145	17·40	21·2	88·3	0·48	0·0089	0·0121	112·	54·	1440	91·5	76·
Annealed Pianoforte Steel Wire (Ewing)	...	...	0·0174	...	...	...	...	...	0·0144	...	...	...	...	...
Porous Iron	25·4	0·604	0·0425	1·66	42·	6·03	10·	0·094	0·0353	10·6	107·	99	268·	223·
„	76·	0·71	...	1·41	107·		30·	0·110	...	9·1	270·	...	...	...
Amalgam of Iron	500·	1·12	0·2314	0·90	447·	12·33	197·	0·173	0·192	5·8	1140·	203	1460·	1220·
Magnetite	8·9	0.2132	0·02348	4·69	41·7	17·56	3·5	0·0330	0·0195	30·	10·6	287	148·	123·
Soft Nickel Wire	1·00	0·17	0·01220	5·88	5·88	13·10	0·394	0·0263	0·01015	38.	14·9	215	77·	64·
Nickel Wire, Soft (Ewing)	...	...	0·0156	...	...	...	...	...	0·0130	...	...	...	...	...
„ Hardened (Ewing)	...	...	0·0365	...	...	...	...	...	0·0320	...	...	...	...	...
Cobalt, Cast	...	...	0·01194	...	...	...	...	...	0·0099	...	...	...	...	...
Coiled Iron Wire, Crossways	86·3	0·	0·0403	...	..	...	34·	..	0·0334	...	...	...	254·	211·
Laminated Iron, Crossways	31·6	0·	0·00721	...	...	...	12·4	...	0·0060	...	...	...	45·5	37·8
Iron Filings, 30 per cent:—														
Electro-Dynamometer Tests	62·5	0·209	0·0465	4·80	300·	38·4	24·6	0·0324	0·0410	31·0	763·	627	312·	259·
Magnetometer Tests	77·5	0·375	0·0656	2·67	207·	20·0	30·5	0·0581	0·0543	17·2	525·	327	413·	342·

AN ELECTRIC BRAKE-DYNAMOMETER.

Many electromagnetic clutches and several brakes have from time to time been invented. Some of the former may come into practical use, especially in cases where it is necessary to manipulate them from a distance, and in case anything goes wrong with the electrical arrangements, a mechanical connection could generally be made. Electromagnetic brakes will probably be received with more hesitation, for a trifling derangement of a contact might lead to a failure, and a failure of a brake generally leads to a more or less serious accident. An ingenious application of an electric brake has been made by M. Pasquilini in a dynamometer for testing small torque high speed motors. A copper disc, Fig. 1, is mounted on the end of a shaft, B. This shaft is attached by a flexible coupling to the motor. An electromagnet, C, is mounted on a shaft, T, and counterpoised by a disc, V. The shaft is supported at T by knife edges, the axis of the

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whole being in a line with that of the shaft B. Four pairs of pole-pieces, K, embrace the edge of the disc, which, therefore, moves in a powerful magnetic field. Eddy currents are thus set up in the copper, and the electromagnet is pulled round by what may loosely be called magnetic friction. Two graduated levers, shown in Fig. 2, are carried by the counterweight V, and by sliding weights on these the pull of the copper disc is balanced. A pointer shows the exact position of equilibrium. The measurement of the power is made as in an ordinary Prony brake.

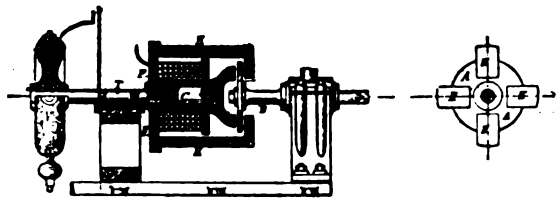

FIG. 1.—Pasquilini's Brake Dynamometer. Section.

An interesting inquiry might be made into the real function of various measuring instruments. In many cases it would be found that the displacement or indication of the instrument is only an incidental feature of the apparatus. A Prony brake is employed as a means of absorbing the load of a motor, and it dissipates the energy in the form of heat. The measurement can often be made and concluded before the pulley has become seriously heated; but if the test be continued some means of cooling must be applied. The dynamometer of M.

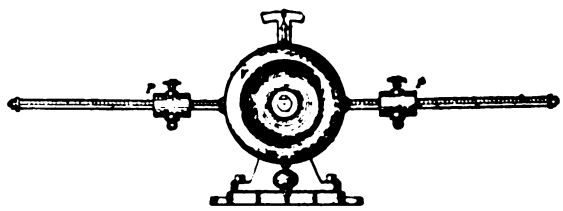

FIG. 2.—Pasquilini's Brake Dynamometer. End View.

Pasqualini effects precisely the same result, but the action is no doubt very superior to any form of friction brake, because there is no absolute contact, and therefore no jumping or binding need be feared, while the regulation of the exciting current, which need not be measured, gives perfect control of the speed. The disc might be run until it is nearly red hot without much danger or inconvenience.

ELECTRIC LIGHT FITTINGS.

In the Notes of our last issue we observed that wall-plugs and lampholders were designed on different lines, and that plugs which would fit into an ordinary lampholder were rarely, if ever, to be found in catalogues of fittings. We are not surprised to learn that such devices are to be purchased, and samples have been sent to us by the General Electric Company and by the Corlett Engineering Company, and a model has been shown us by Messrs. Evered and Co. The plugs supplied by the General Electric Company are of two patterns, one intended for use with a bayonet holder, and one for an Edison socket. These, we understand, will be included in a catalogue which will be issued by this firm next week. The plug, Fig. 1, is of porcelain, and resembles the brass cap of a lamp, except that the pins are rather longer. A screw cover protects the terminals, which are provided with round nicked nuts. A bridge of porcelain stands up between the terminals and serves, as in lampholders, to keep the stray wires apart, and to take the strain of the wires which pass through transverse holes in it. The wall-socket consists of an ordinary lampholder, in which the nozzle and cap have been replaced by a flange. A drawback to such an arrangement for wall-sockets is, that the spring plunger contacts are easily accessible when the plug is out, and, as we suggested last week, special design is needed. Any of these locking sockets might be used for ceiling roses, with great advantage in some places. This protection of the contacts would only apply where the sockets are within reach, and where they are likely to be left open. The other plug (Fig. 2) is of the Edison type. This is a favourite form with many people, and the lampholders of this pattern have certain advantages. It seems natural to find that the body of this plug is made of wood, boxwood it is true, and neatly turned but both electrically and æsthetically it is inferior to the porcelain sample; mechanically also, since there is no provision for taking the pull of the wires. It should be remembered

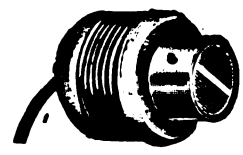

FIG. 1.

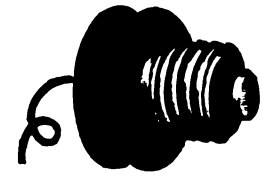

FIG. 2.

that where a wall-plug is locked into the socket, as in these cases, the flexible cord is liable to receive accidental tugs, and these, when due to an unwary person tripping over or catching his foot in the loose wires, are good for trade, especially for the art fittings department. The plug sent us by the Corlett Engineering Company consists of a small black wooden handle, about the size of a small bradawl handle. It is finished like a brass capped lamp, but the wires seem to be permanently fastened. At all events we have not succeeded in opening it.

A new wall-socket has been sent us by Messrs. Evered and Co., not in connection with our remarks about interchangeability with lampholders, for we received it before these appeared. It is very substantially made, and is itself a switch. A bayonet plug makes contact with the ring into which it fits, and an end contact when it is pushed home. We understand that in the latest form this is not a mere pressure contact of the flat spring D with the head E, as shown in the illustration, but that a spring plunger contact is provided. We are glad also to learn that the vulcanised fibre which was used for insulation in the sample sent to us has been dispensed with, since, excellent as its mechanical qualities are, this material is quite unsuitable for insulation in electric light fittings. The plug bayonets firmly into the socket, and in turning it, the switch C is moved over

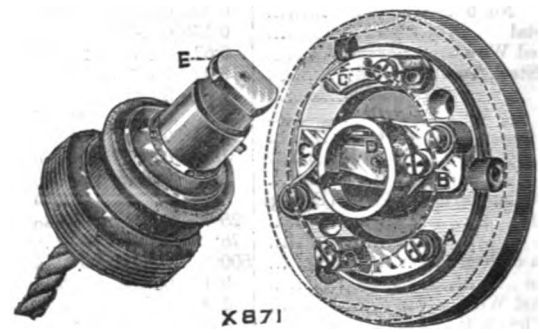

FIG. 3.

to the position G, thus completing the circuit. A cheaper form is made without the switch, and both kinds are provided with a fuse. This form of socket is much more easy to use in the dark than the common two-prong pattern; but having a single bayonet pin, it might have to be turned round a good deal before getting it fixed. Nothing can be more annoying than trying to fit a two-prong plug in an awkward position near the floor in the dark.

Among the ingenious devices brought out some seven years ago by the Vitrite Company plugs of the lampholder pattern were made. These could be used for attaching flexible wires to lampholders, or as connectors for pendants. Connectors were first made, we believe, by Messrs. Faraday and Co., about the size of an acorn, and called "acorn connectors." They were made of boxwood covered with brass cups and enabled a pendant fitting to be taken down or exchanged. We

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have heard nothing of these for years past. If we are not mistaken, the Vitrite Company made a rather ugly socket into which either a lamp or a connector plug could be fitted, but the material was not suitable for use in large masses, but neither these nor the plugs appear in modern catalogues.

Attention to some of these minor fittings would help to popularise electric light in small houses where the little conveniences would be better appreciated, perhaps, than in larger establishments. One cannot have every advantage at the same time. Nothing can be more convenient as a plug than the plain concentric pattern, which will go in at once as soon as the one hole is found; but its admirable simplicity would be lost if any locking or switching device were added.

Messrs. Evered have also sent us a shadeholder, Fig. 4, for carrying large shades. By pressing together the handles A A the clips B B B are drawn towards the centre, the shade is then placed in position, and the handles are released, the spring C forcing the clips outwards, and firmly holding the shade, even if it varies from the standard size, and whether made with or without a lip. No set screws are used in this

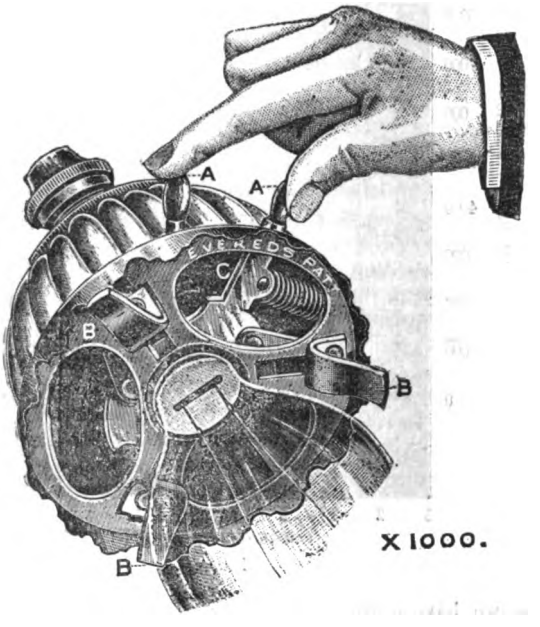

Fig. 4.

holder, and the brass dome, which is made as in the illustration, or with perforated ornamentation, fits between the usual shadeholder rings on ordinary lampholder.

ON JOINTS IN MAGNETIC CIRCUITS.*

BY PROF. EWING, F.R.S.

In the *Philosophical Magazine* for September, 1888, an account was given by Mr. William Low and myself of experiments we had made to examine the influence of a plane of transverse section in an iron bar which formed part of a magnetic circuit. It was found that a transverse cut introduced what is now frequently spoken of as magnetic resistance, even when the faces at the cut were scraped up to be as nearly as possible true planes, and were brought into excellent mechanical contact. Only when a very considerable force was applied to press them together did the resistance of the joint appear to vanish; except in this case it required a stronger magnetomotive force—a greater number of ampere turns in the magnetising coil—to bring the magnetic induction up to any assigned value when the bar was cut than it had required when uncut. In this respect the joint is equivalent to a narrow crevasse of air or other non-magnetic material. We proceeded to calculate the width of the air-gap, which should be equivalent, in magnetic resistance, to the joint, and obtained values which made it appear that the width of this equivalent air-gap became reduced when the magnetisation was forced up to high values. Having occasion recently to revise these results I found that an incorrect procedure had been followed in calculating, from the experimental data, the width of the equivalent air-gap. When the necessary correction is made it appears that this width remains constant, or nearly constant, whether the magnetisation be weak or strong. The object of this note is to point out the error in the former calculation, and to state the corrected values.

* From the *Philosophical Magazine*.

Suppose we have to deal with the magnetisation of a complete iron circuit, of uniform cross section, and of length l. Let the permeability of the iron be μ, for any induction B. The line-integral of magnetic force producing this induction is $\frac{Bl}{\mu}$, when there is no joint. Next suppose a joint to be introduced and to be equivalent in magnetic resistance to an air-gap of width x. The line-integral of magnetic force is then

$$\frac{Bl}{\mu}+Bx.$$

Distinguish by dashes the values of B and μ in this case from their values when there was no joint. Then, taking the same number of ampere-turns in the magnetising coil in both cases, we have

$$\frac{Bl}{\mu}=\frac{B'l}{\mu'}+B'x;$$

from which

$$x=\frac{l}{B'}\left(\frac{B}{\mu}-\frac{B'}{\mu'}\right).$$

In the Paper referred to we omitted to take account of the variation which the permeability of the iron undergoes when B is changed to B'. It is, however, essential to distinguish between μ' and μ if the plan is followed of finding x by comparing the inductions reached in the two cases under equal values of the magnetomotive force.

A better way, however, is to draw the curve of magnetisation in relation to magnetomotive force for each of the two cases, and then find, by measurement from the curves, what is the difference in magnetomotive force for one and the same value of the induction. This simplifies matters by securing that μ shall be the same when there is a joint as when there is none. If we write H for the magnetic force when there is no joint, and H' for the mean magnetic force required to produce the same induction B when there is a joint, we have

$$Hl=\frac{Bl}{\mu},$$

and

$$H'l=\frac{Bl}{\mu}+Bx;$$

from which

$$x=l\left(\frac{H'-H}{B}\right).$$

Thus, let a curve giving B and H be drawn, and another curve, with the same axes, giving B and H', then the distance between the curves measured parallel to the axis of H, when divided by the corresponding value of B, is proportional to the width of the equivalent gap. When this method is applied to the experimental results which were published in the Paper referred to it will be found that, for any given joint, the values of H' − H are nearly proportional to B. In other words, x remains nearly constant instead of becoming diminished as the magnetism is pushed towards saturation. One or two instances may be quoted.

In Table I. experimentally found values of the magnetic force due to the magnetising solenoid are given, along with the inductions observed when there was no joint and when there was a joint. The joint in this case was between carefully finished surfaces, approaching the condition of true planes. No externally applied mechanical force was used to force the surfaces together.

Table I.—*Influence of a Smooth Joint in an Iron Bar.*

Magnetising force due to solenoid.	Magnetic induction B.	
	Without joint.	With joint.
4	3,950	3,000
6	6,900	5,300
8	9,250	7,400
10	10,900	9,150
15	13,250	12,000
20	14,300	13,500
30	15,200	14,900

In Fig. 1 these results are shown by curves, and a third curve (the dotted line) is added to show the values of H' − H in terms of B. It will be seen that this curve is nearly a straight line; it should be straight if the magnetic resistance of the joint were strictly constant. Table II. gives values of the width of air-gap equivalent in magnetic resistance to the joint, as determined from this experiment.

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Table II.

B.	Width of air-gap equivalent to the joint, in centimetres.
4,000	0·0026
6,000	0·0030
8,000	0·0031
10,000	0·0031
12,000	0·0035
14,000	0·0037

Data relating to a second experiment in which a cut with true-plane surfaces was introduced in another iron bar will be found in another Paper. Fig. 2 shows the graphic treatment of this example, and it will be seen that the dotted curve which exhibits $H' - H$ is in this case slightly concave towards the axis of B,

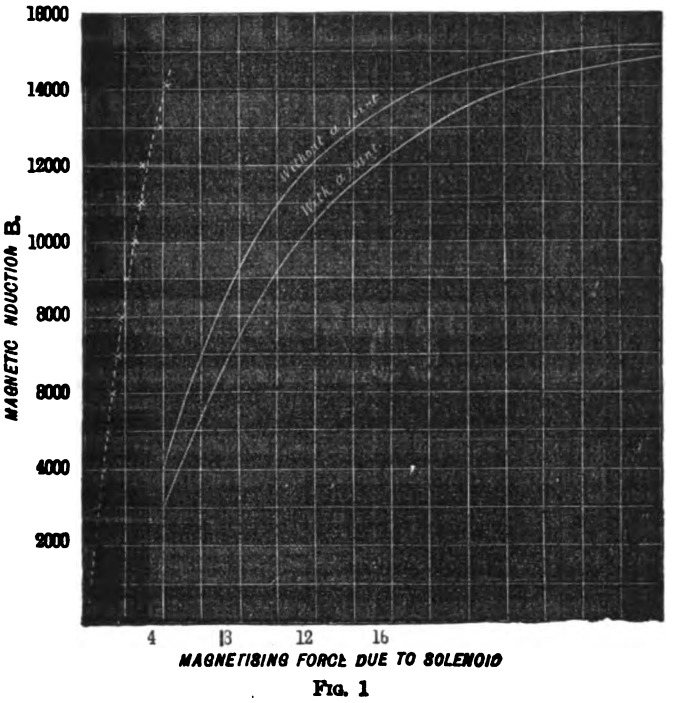

Fig. 1

whereas in the former example it was slightly convex. The deviations from straightness are in neither case more than may well be set down to uncertainty in the experimental data; and taking the two examples together it seems very probable that the joint is equivalent to an air-gap of sensibly constant magnetic resistance.

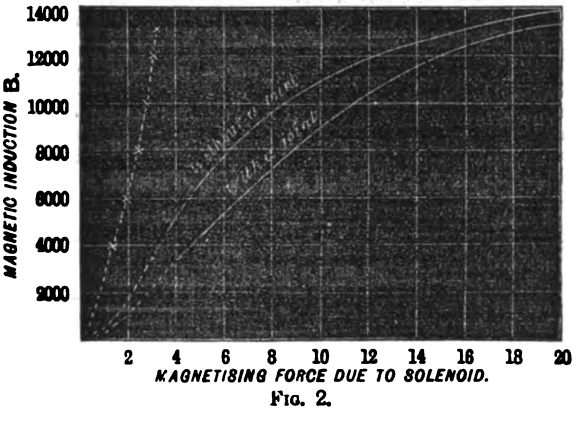

Fig. 2.

In the first example the width of the equivalent gap was about 0·0033cm.; in this case its mean value is about 0·0036cm.

Small as these gaps are, it is difficult to believe that the metallic surfaces were actually separated so far, and it seems more probable that the magnetic resistance of a joint is due in part to a reduction of permeability in the metal itself at and close to each surface, as a result of the influence of surface conditions in affecting the grouping of the molecular magnets.

Since the joint is equivalent to an air-gap of sensibly constant width it is easy to apply a graphic construction, like that used by Lord Rayleigh in the case of ellipsoids,* to determine the influence which the joint must exert in any cyclic or other magnetising process: or, conversely, to determine from experiments made on a circuit in which there is a joint the form which the magnetisation curve would assume if the joint were not there. The effect of a gap or of a joint is to make the true magnetic force less than the apparent magnetic force (namely, the force due to the magnetising solenoid), by an amount which is proportional to the magnetisation. We have $H = H' - \frac{Bx}{l}$. Thus a curve giving the relation of B to the magnetising force in a ring without a joint will serve to show the relation of B to the externally applied magnetic force on a ring with a joint if we re-draw it, merely shearing it over by inclining the axis along which B is represented through an angle the tangent of which (interpreted upon the proper scale of B and H) is equal to $\frac{x}{l}$. To take a practical instance, sup-

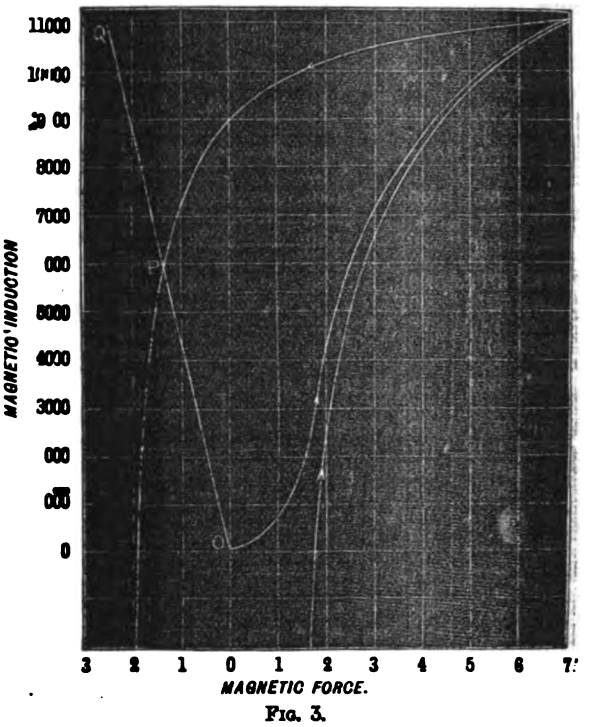

Fig. 3.

pose we have a ring of soft iron forming a magnetic circuit say 30 cm. long. Suppose the ring, when tested in the solid state, to give the curves B and H, shown in Fig. 3, which are actual curves for a soft wrought-iron ring. Let it be required to deduce from these curves the relation which the magnetism would have to the externally applied magnetising force if the ring, instead of being solid, were cut into two half rings, with carefully faced ends placed in the best possible contact. Each cut, as we have seen, is equivalent to a gap $\frac{1}{300}$ cm. wide. The two together make x equal to $\frac{1}{1500}$ of the length of the ring. Hence, if we draw a line O P Q in the figure inclined, so that H is—1 when B is 4,500, the intercepts between it and the axis of B represents the self-demagnetising forces due to the cuts at all stages of the magnetising process. Curves giving the applied force H′ in relation to B for the cut ring may then be drawn by using as abscissæ the distances of points on the original curves from the line O P Q, measured parallel to the axis of H. The reverse of this construction will, of course, serve to deduce true magnetisation curves (for uncut metal) from experiments made with a magnetic circuit which contains a joint or a gap.

The figure is drawn to scale for an actual case, and serves to show that the division of a ring 30cm. long into two half rings abutting against each other with the smoothest possible joints has the effect of reducing the residual magnetism from 9,000 to 6,000, which is the height of the point P. A similar shearing over of the curves, with consequent reduction of the residual magnetism occurs, to a greater or less extent, in magnetic tests of bars when these are made to form part of a complete magnetic circuit by the addition of a massive iron yoke.

* *Phil. Mag.*, August, 1886, p. 180.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have decided, after placing £14,000 to the reserve fund, and £6,610. 10s. to the debenture redemption fund, to recommend at the forthcoming meeting a dividend of 3s. per share, free of income tax, being at the rate of £2 per cent. per annum for the six months ended June 30th last, carrying forward £1,662.

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UNDERGROUND MAINS IN PARIS.

The frequent references to the subject in the technical Press and the frequent accounts of explosions in the daily Press would seem to show that the Paris electric lighting companies are experiencing more trouble with their bare copper "canalisations" than is the case in London. Some few months since (*The Electrician*, Vol. XXVIII., p. 664) M. J. A. Montpellier propounded a theory and a remedy in the columns of *L'Electricien*, and below we reproduce, nearly in its entirety, an article by M. G. Claude which appeared in the last issue of *L'Industrie Electrique*.

The accidents, becoming every day more frequent, occurring in the vicinity of continuous-current mains make it clear that these "canalisations" possess defects which it was impossible to foresee, and which can only be got rid of by taking minute precautions. The phenomena are of different kinds, but the more common, presenting, moreover, the most features of interest, are somewhat as follows:—Gas pipes running near continuous-current mains become pitted all over and perforated in places. On the other hand, the stoneware conduit, or trough containing the conductors, is filled at these points with a mass of soda and potash salts, sometimes to the extent of several kilogrammes, although externally the conduit exhibits no sign whatever of being attacked. The conductors themselves, and especially the negative main, are so powerfully attacked that conductors having a cross sectional area of 40 sq. mm. (·06 sq. inch) have been ruptured. It is not a question of a particular instance, but of a phenomenon common to all the Paris electric lighting districts. Generally, the parts affected are the secondary mains, which are laid with less care, the conductors being run through stoneware without any insulators. It is also the branch lead gas pipes, which are often very close to the conductors, that are attacked. There are, however, several instances of tarred cast-iron and sheet-iron gas pipes being attacked. I have observed on a 50 cm. length of 20 cm. cast-iron gas-piping a dozen pittings 6 to 8 mm. deep, and from 1 to 3 mm. in diameter. Owing to the heat generated in the surrounding soil, and the proximity of the continuous-current mains, it was impossible to suppose other than an electrical origin to these pittings. The water pipes have not as yet been affected, simply because the mains and branches are not laid directly in the ground, but are placed in the sewers.

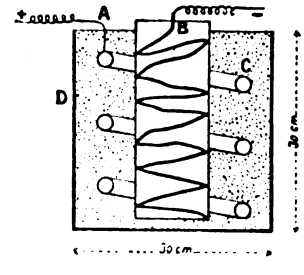
It has been sought to explain the street explosions by accumulations of electrolytic hydrogen in the conduits. But on examining the locality, it was found in the case of the Rue Notre-Dame-de-Lorette explosion that 52 gas branch pipes were perforated. The progress of the phenomenon is somewhat as follows:—Insulation at first satisfactory, progressively diminishes; small quantities of alkaline matter, due to slow electrolysis of the salts contained in the soil, soon reach the conductor; from this moment the insulation falls rapidly. The walls of the conduit, traversed by a stream of alkaline substances, acquire a continually-increasing conductivity. A large basic deposition takes place inside, the cable is corroded, and the leakage current may amount to 13 to 15 amperes, and the soil warms up for a considerable distance around. As the electrical and the gas mains are attacked simultaneously, it is easy to see how grave these accidents might become under certain circumstances, and how important it is that precautionary measures should be taken. Several of the companies concerned, and especially the Gas Company which is directly interested in the matter, have been moved by this state of things to undertake numerous investigations, with the view of elucidating the mechanism of these phenomena. The large amount of work which the Edison Company is carrying out at several points on its system are in some measure the result of these investigations. The following is the outcome of researches carried out by myself:—

An analysis of the alkaline deposits found in the conduits showed that their composition is sensibly constant. Several samples were made up as follows:—Soda, carbonate of soda, potash, carbonate of potash, lead, in large quantities; alumina, copper, lime, in appreciable amounts; traces of iron and silica. The presence of a considerable proportion of lead is interesting, and affords us a valuable index to the nature of the perforations. It proves, in fact, that they are not due to local fusion, an hypothesis in any case difficult to admit, but to electrolytic transportation. In some samples, however, lead was not to be found, and was replaced by iron, which was due to the fact that the current was directed on to tarred cast-iron or sheet-iron pipes.

This first point established, I endeavoured to reproduce the perforations. The arrangement which gave the best results was as follows:—A (*see* Figure) was a porous vessel, intended to represent the stoneware of the conduit, whilst having at the same time a lower resistance. B was a strip of German silver, bent so as to make as many contacts as possible with the sides of the vessel, and connected to the negative pole of a 120-volt circuit. C was a lead pipe wound round the porous vessel and connected to the positive pole. In order to localise as much as possible the attacks on the lead the pipe was covered with a coat of varnish very unequal and very thin at places. The whole was enclosed in a box, D, filled with a slightly moist mixture of sand and sea-salt. On applying 120 volts pressure all the phenomena observed on the mains were reproduced. The current, at first almost zero, gradually increased to more than 0·75 ampere. Tufts of alkaline matter soon formed at every point of contact of the German silver strip, and they grew in size during the entire experiment. At the same time the temperature rose to about 75°C. As to the pipe, at every spot where the layer of varnish, owing to its thinness, offered a low resistance, it was bleached by the action of chlorine, and the metal parts which it covered were riddled with pittings 1 to 2mm. deep and 2 to 3mm. in diameter.

These facts, which are in exact agreement with what was observed in the conduits themselves, seem to justify the following conclusion:—(1.) The perforations certainly do not arise from local fusion, since the current is always very weak. (2.) The size of the perforations is much too great for them to be due simply to transformation into chloride of the lead corresponding to the chlorine liberated by electrolysis. (3.) The proportion of chloride of lead found around the pipe is, on the contrary, very small; and again lead is found in the alkaline matter deposited on the negative electrode. At times, also, the formation of the tufts was accompanied by deflagrations, due either to the combustion of the sodium or to a too powerful local current. These deflagrations occurring in an atmosphere charged with gas may explain explosions which have taken place.

From these various observations we may conclude with some degree of certainty that things take place in the following manner:—The chlorine arising from the electrolysis finding itself in a nascent state in presence of lead forms first of all chloride of lead, but this compound being traversed by an electric current is electrolysed as fast as it is formed. The lead is carried to the negative pole, when it mixes with the soda and potash, whilst the regenerated chlorine attacks the subjacent layers of lead, which it penetrates more and more. Moreover, the resistance of the parts attacked becoming less



and less by reason of the stream of metallic matter, we can see that any fresh chlorine tends to go to these spots, and thus the depth of the holes tends to constantly increase, although the chlorine liberated may be very limited. In this way, also, is explained the transportation to the negative pole of the lead, to which the chlorine serves as a sort of vehicle; and also the almost complete absence, with the exception of a few white specks, of lead salts around the pipes attacked. This explantion is susceptible of a still simpler verification. If we subject a concentrated solution of chloride of sodium to electrolysis (which is what we do when we electrolyse soil only slightly damp), using as positive electrode a strip of lead, and as negative electrode a piece of carbon, the lead is attacked very rapidly, and a white precipitate of oxychloride of lead is formed and an appreciable proportion of the lead attacked is deposited on the negative pole.

In all that precedes I have supposed that the gas mains were in communication with the positive pole of the electricity supply. It may equally well happen that they are in communication with the negative pole, and in that case the effects produced should be different. Theoretically, the chlorides are still electrolysed as soon as the insulation of the "canalisation" falls below a certain value; the alkaline bases are carried to the lead pipe on which they can only have a feeble effect, whilst the chlorine is carried on to the conductor which it eats away, forming chloride of copper. In practice this class of phenomenon has not been observed. This is due probably to the fact that the passage of the chlorine through the stoneware does not lower the resistance as much as the passage of the soda and potash, and consequently this phenomenon cannot exhibit the constant growth which characterises the ordinary phenomena.

It may be concluded from the above that up to the present, with rare exceptions, the precautions taken to ensure the insulation of the continuous-current systems have proved insufficient, owing to the influence of a factor the importance of which could only be gauged by experience. The simple drawing in of cables through stoneware conduits should be absolutely prohibited, and even with insulated cables we should not be content to employ enamelled iron hooks, which become rusty, and offer a passage to soda and potash

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salts. It follows, also, from these investigations that especial care should be taken with regard to the insulation of the positive main, since injury to neighbouring mains seems to have always been the result of communication with the positive. If, in laying down an electrical network, the two conductors will not be under equally favourable conditions, the positive should have the best position. Finally, a new solution of the problem is indicated by this investigation, which consists in adding to the good insulation of the positives a metallic connection between the negative and the neighbouring mains having a sufficient resistance to prevent accidental short circuits, say 50 to 100 ohms. We must make our choice. Either the insulation of the positive is sufficient, and will stand this earthing of the negative without inconvenience, or the precautions taken are insufficient, the insulation will go on decreasing, and after a long time electrolysis will again commence to take place. But now the neighbouring pipes being at the same potential as the negative will only receive alkaline deposits, the effect of which will only be slight, at first owing to the fact that their erosive action is much less than that of nascent chlorine, subsequently because the conditions of the case are antagonistic to the electrolytic transportation of lead. Reversals of polarity, and the accidents which arise from them, can then only take place when the insulation of the positive has fallen below that of the resistance connecting the negative to earth ; that is to say, when the faults are easy to localise and repair. In any case, the companies would only on this hypothesis have to do with defects of their own insulation, and other mains would be protected, which would be a great improvement. A still more radical cure would be to substitute alternate for continuous currents ; alternate current mains do not possess the same sources of deterioration, and, as we know, keep in a better state. But to realise this idea great progress will have to be made in the work of rendering alternate currents susceptible of applications as general and as convenient as is the case with continuous currents.

THE AGE-COATING IN INCANDESCENT LAMPS.*

BY EDWARD L. NICHOLS.

When an incandescent lamp is maintained at constant voltage it invariably falls off in candle-power. The diminution in brightness is attended by an increase in the amount of energy consumed per candle-power of light, this change being specially marked in the earlier portion of the life of the lamp. This phenomenon, which seems to take place in all incandescent lamps of the present day, was first studied exhaustively by Mr. W. H. Peirce, who read a Paper entitled "The Relation between the Initial and Average Efficiency of Incandescent Electric Lamps," before the American Institute of Electrical Engineers, in 1889.† Mr. Peirce made a careful study of 94 lamps, including nearly all the types of glow-lamp then in use. He found no exception to the rule of progressive degeneration.‡

These changes may be ascribed to at least three causes : loss of vacuum ; increase of resistance, due to the disintegration of the filament ; and finally, the deposition of the disintegrated carbon upon the inner surface of the lamp-bulb. It was the object of the experiments to be described in this Paper to make a study of this coating. We endeavoured (1) to determine its character—that is to say, whether it is colourless or is selective in the particular rays it absorbs ; (2) to learn something about the rate and distribution of deposit ; and (3) to determine how far the absorption of light by the coating is accountable for the diminution in the brilliancy of the lamp.

For the determinations under the first head we made use of a form of polarising spectro-photometer, which has been more than once described.§ The standards of light were incandescent lamps. These were maintained at a candle-power considerably below the normal, that the changes taking place in them might be slow. Frequent comparisons of their spectra showed that the relative changes of brightness and quality of light were inappreciable. The first step in our investigation consisted in the measurement of the absorption spectra of the bulbs of certain unused lamps, which had been selected for study. These lamps were then brought to degrees of incandescence, previously agreed upon, and were maintained in that condition by means of the current from a storage battery carefully kept constant, until they showed coatings of sufficient density to admit of ready measurement, They were then taken out of circuit, and the absorption spectra of the blackened bulbs were determined. These readings gave the amount of light of each wave-length absorbed, and, by repetition, the rate of deposition during different periods of the lamp's existence. The entire set of photometric observations were duplicated, but since the final results obtained by the two independent observers (Moore and Ling) were in agreement, only the mean of the two sets is given in the following tables.

In order to ascertain precisely what part in the decadence of the lamp is attributable to the coating, it was necessary to keep careful watch of the continually shifting electrical and photometric conditions during its entire life ; and in order to maintain in each lamp the precise conditions under which it had been determined that it should be burned, measurements of candle-power and voltage had to be made at short intervals, together with continual readjustments of the current. Fourteen lamps in all were selected for the investigation. These were of two widely different types, representing the two great classes, viz., lamps with untreated and with treated filaments. Of these, some were maintained at the voltage indicated by the maker, or at predetermined constant voltages other than this. Others were kept at constant candle-power throughout their entire life, the current being increased whenever the decrease in brightness due to increasing age had become appreciable. From the data obtained in this way, the life curves of the various lamps were plotted, showing the variation in candle-power or voltage respectively, of resistance and of efficiency expressed in watts per candle, during its entire existence. Some of these curves have already been published.* As these results were quite in accordance with those obtained by Mr. Pierce, to which reference has already been made, it will be necessary to deal with them here only in so far as they bear upon the question of the influence of the age-coating upon the efficiency of the lamp.

Colour of the Coating.

Measurements upon all fourteen of the lamps which were subjected to the spectro-photometric tests, showed the colour of the coatings upon lamp-bulbs containing treated and untreated carbons respectively, to be practically identical in character. The colour of the coatings obtained in lamps of either type, under widely diverse conditions (as, for example, by maintaining a 16 c.p. lamp at 64 candles throughout its life), was the same as that produced under normal conditions of service. The colour in question is very nearly neutral, the percentage of light transmitted being approximately the same for all parts of the visible spectrum. The effect of the "*age coating*," as the deposit which we are considering may be called, is therefore to dim the lamp, without appreciably changing the quality of its light.

The most complete set of observations obtained with lamps of untreated carbon are those referring to a lamp designated in our list as No. 2.† This lamp was maintained at normal voltage for over 800 hours. Frequent readings of candle-power and current during this time afforded the means of tracing the progressive changes of light-giving power, efficiency, and resistance. Measurements of the age-coating were made after 100, 200, 400, and 800 hours of life, readings being taken in ten regions of the spectrum. The results are given in Table I., together with data indicating the condition of the lamp at the above-mentioned periods of its life. These are taken from a set of 67 readings of voltage and current, distributed over the entire life of the lamp at nearly equal intervals. The variation in voltage during the entire 800 hours was never more than 0 3 volt above or below the initial value.

Another typical case was that of lamp of No. 10, which was a lamp with a treated filament. It was maintained at a very different degree of incandescence, being a lamp of low efficiency, which, when set at the voltage indicated by the manufacturer, required an expenditure of 5·16 watts per candle. The age-coating of this lamp approached even more nearly to complete neutrality of shade than did most of those which we had occasion to measure. The results obtained at 200 and 900 hours are given in Table II.

The normal life of a lamp starting at 5 watts per candle is many thousands of hours. Lamp No. 10 was prematurely broken at 908 hours, at which time the coating had reached a density corresponding to that of a 3-watt lamp (No. 2) after 200 hours of life. A comparison of Tables I. and II. will show that while the coatings on these two lamp bulbs were not quite neutral nor precisely identical in tint, that they both transmit light with much greater uniformity than do such materials, for example, as optical glass, calcite, &c.‡

* From the *American Journal of Science*, Vol. XLIV., October, 1892. Experimental work by Messrs. B. E. Moore and C. J. Ling. Contribution from the Physical Laboratory of Cornell University.

† *The Electrician*, Vol. XXIII., p. 177.

‡ Since the above was written an extended investigation upon this subject has appeared. It entirely confirms the results obtained by Mr. Peirce. *See* "A Life and Efficiency Test of Incandescent Lamps," by Prof. B. F. Thomas and Messrs. Martin and Hasler, *The Electrician*, July 29, p. 330.

§ *Phil. Mag.*, XXXII., p. 404, November, 1891.

* "The Artificial Light of the Future." *The Electrician*, Vol. XXVI., p. 147.

† This and other numbers used refer to the records of these experiments as given in full in the thesis of Messrs. Moore and Ling, a manuscript deposited in the Library of Cornell University. ("The Life and Duration of Incandescent Lamps, with Special Reference to the Light Absorbed by the Coating within the Bulb." By B. E. Moore and C. J. Ling. 1890.)

‡ See Kruess, Kolorimetrie, p. 243 ; also, Nichols and Snow, *Phil. Mag.*, Vol. XXXIII., p. 379. April, 1892.

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Table I.—*Lamp No. 2 (untreated filament).*

Initial Conditions.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·8	0·474	214·8	16·00	3·015

Conditions after 100 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·9	0·453	225·3	12·50	3·697

Light transmitted by the coating, after 100 hours.

λ = 0·750	88·9 per cent.	λ = 0·507	92·2 per cent.
0·713	90·2 „	0·481	92·8 „
0·635	91·8 „	0·460	92·3 „
0·658	91·5 „	0·443	92·4 „
0·538	91·9 „	0·429	92·4 „

Conditions after 200 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·8	0·421	225·9	10·6	4·250

Light transmitted by the coating after 200 hours.

λ = 0·750	83·5 per cent.	λ = 0·507	86·4 per cent.
0·713	84·5 „	0·481	86·9 „
0·635	85·6 „	0·460	87·6 „
0·580	85·4 „	0·443	87·9 „
0·538	85·9 „	0·429	85·4 „

Conditions after 400 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·8	0·428	237·7	9·67	4·510

Light transmitted by the coating after 400 hours.

λ = 0·750	79·3 per cent.	λ = 0·507	83·5 per cent.
0·713	80·9 „	0·481	83·6 „
0·635	82·3 „	0·460	84·0 „
0·580	82·0 „	0·443	84·3 „
0·533	82·6 „	0·429	82·1 „

Conditions after 800 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·9	0·415	245·6	7·20	5·880

Light transmitted by the coating after 800 hours.

λ = 0·750	75·7 per cent.	λ = 0·507	78·7 per cent.
0·713	75·9 „	0·481	79·4 „
0·635	78·0 „	0·460	79·9 „
0·580	78·6 „	0·443	80·5 „
0·538	78·4 „	0·429	77·3 „

Table II.—*Lamp No. 10 (treated filament).*

Initial Conditions.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
36·0	1·171	30·63	8·2	5·16

Conditons after 200 Hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
35·9	1·145	31·27	7·1	5·91

Light Transmitted by the Coating after 200 Hours.

λ = 0·750	91·9 per cent.	λ = 0·507	90·7 per cent.
0·713	90·4 „	0·481	90·4 „
0·635	89·5 „	0·460	90·7 „
0·580	90·5 „	0·443	90·5 „
0·538	90·5 „	0·429	90·4 „

Conditions after 908 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
36·14	1·14	31·70	(un-	known)*

* The lamp was broken before the photometric measurements had been completed.

Light transmitted by the coating after 908 hours.

λ = 0·750	86·6 per cent.	λ = 0·507	84·5 per cent.
0·713	85·2 „	0·481	85·0 „
0·635	83·1 „	0·460	85·5 „
0·580	83·6 „	0·443	86·0 „
0·538	84·5 „	0·429	86·0 „

The Distribution of the Age-coating within the Bulb.

The distribution of the age-coating was determined indirectly as follows:—Two of the lamps under examination were measured for horizontal candle-power, according to the "Franklin Institute" method;* measurements being made in 12 meridians, 30deg. apart. The readings were repeated at frequent intervals throughout the life of the lamps. The results were plotted with polar coordinates. They show (Fig. 1) by the diminishing area of the successive curves

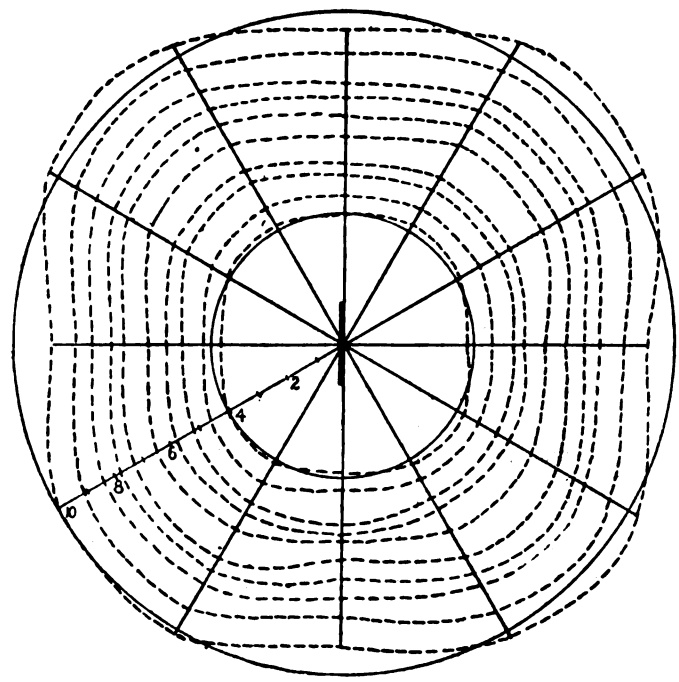

Fig. 1.

the progressive loss of brightness due to age, of which about one-half is ascribable to the coating. The similarity of the curves, from first to last, indicates that the coating is deposited uniformly within the bulb, or in uniform lateral zones, so that the density of the film is symmetrical with reference to any given meridian. The case chosen for illustration is lamp No. 7. The results obtained with lamp 8 were in every essential respect the same as those shown in the diagram.

The Age-Coating considered as a factor in the Diminishing Efficiency of the Lamp.

It may be seen from the Tables (I. and II.) that the absorbing power of the coating is in itself sufficient to account for a very considerable falling off in the candle-power, as the lamp, within the bulb of which it forms, grows old in service. By summation of the values in the tables, we may obtain the average absorbing power for the entire spectrum; and since selective absorption is almost entirely absent, these averages will give very closely indeed the loss in candle-power, which at the time in question was ascribable to the influence of the coating. From the data in Tables I. and II., also, we may compute the efficiencies of the lamps at various stages in terms of their initial efficiency as unity; likewise their brightness from time to time, in terms of their initial candle-power, as unity. In Tables III. and IV. are given, for purpose of

* *See* Franklin Institute Tests (International Electrical Exhibition, 1884), Philadelphia, 1885.

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comparison, the relative brightness and efficiency of lamps 2 and 10, at various periods, also the average absorbing power of their coatings.

Table III.—*Relative Brightness, Efficiency, and Transparency of Lamp No. 2, at Various Periods (each expressed in terms of its initial value, taken as 100).*

Time.	Relative brightness.	Relative efficiency.	Relative transparency of bulb.
000· hours	100·	100·	100·
100 „	78·1	81·5	91·44
200 „	67·5	70·9	85·91
400 „	60·4	66·8	82·46
800 „	45·0	51·3	78·24

Table IV.—*Relative Brightness, Efficiency, and Transparency of Lamp 10, at Various Periods (each expressed in terms of its initial value, taken as 100).*

Time.	Relative brightness.	Relative efficiency.	Relative transparency of bulb.
0· hours	100·	100·	100·
50· „	92·6	92·6	—
109· „	91·4	90·1	—
200· „	86·6	87·3	90·5
400· „	80·5	81·6	—
511· „	78·7	80·0	—
600· „	78·0	79·5	—
900· „	—	—	85·0

The curves in Fig. 2 are based upon these data. They show that the loss in candle-power and efficiency are only in part due to the opacity of the coatings. It is of some interest to compare lamps

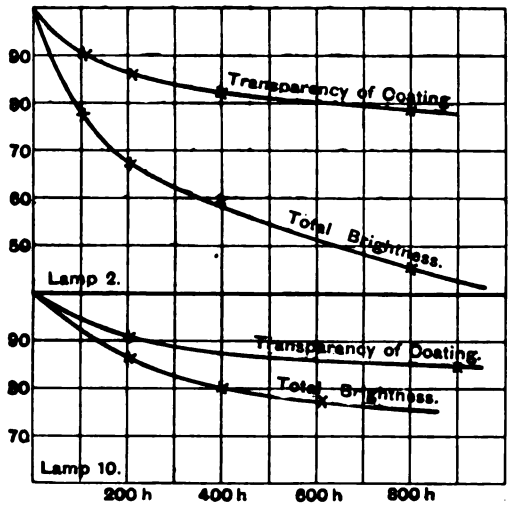

Fig. 2.

2 and 10, since the former is a 3-watt lamp, whereas the other required 5·16 watts per candle at the beginning of the test. It is to be regretted that the tests did not extend over the normal life-time of such a lamp; the results obtained, however, suffice to show that the loss due to coating is a much larger portion of the total loss in the low-efficiency lamp than in the other. Measurements with several lamps, maintained at abnormally high temperatures, seemed to indicate that the higher the state of incandescence the less marked (relatively) is the influence of the age-coating upon the decadence of the lamp.

Summary of Results.

1. The rate of deposit of the coating in incandescent lamp bulbs is greatest in the early part of the life of the lamp. For example, in the case of a lamp which lasted 800 hours (*see* Table III.) more than half of the coating was deposited during the first 200 hours.

2. The loss of brightness due to the absorbing power of the age-coating is a variable part of the total loss, being greatest in lamps of high initial efficiency.

3. The coating does not appreciably modify the character of the light which emanates from the lamp.

4. The distribution of the coating within the bulb is a nearly uniform one (*see* Fig. 1).

5. No marked difference between treated and untreated filaments appears to exist, as regards the density or quality of the coating produced from them.*

CORRESPONDENCE.

THE PRINTING OF MATHEMATICAL SYMBOLS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Having read the correspondence and Editorial Note on printing mathematical symbols in your last two numbers, I should like to offer the following suggestions:—

(1.) Fractions can always be printed like dx/dy by using parentheses; *e.g.*, your own example, $\frac{Im - L\omega}{Im + L\omega}$, would be printed $(Im - L\omega)/(Im + L\omega)$, without danger of ambiguity, and so on for even very complicated fractions.

(2.) Why not denote exponents thus: $|x|$; *e.g.*, $A\epsilon^{-ax}$ would be printed $A\epsilon|-ax|$, and so forth.

I am not aware of any usage of similar vertical lines which would cause confusion.—Yours, &c., R. Duncan.

Crowthorne, Berks, Oct. 15, 1892.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: May I point out that your criticism on my suggestion of the symbol $\epsilon\overline{\backslash -ax}$ to represent ϵ to the power $-ax$, that it breaks the "leading," does not apply to my alternative suggestion of the symbol $\epsilon\backslash(-ax)$. But it is, of course, for practical printers to decide on the question whether any plan, supposing it otherwise acceptable, saves them expense and trouble. The essence of the suggestion is to use the line \ to throw up the exponent, using at the same time a bracket of some kind to show what is the exponent if it be not a single letter. The exponent in its usual place is practically bracketed by being all above the line. If you bring it down, you must insert an actual bracket of some sort to show its extent. The underline would be the best under the circumstances, if practicable. I suppose that even if used with type for the index of a smaller size, thus, $\epsilon\underline{\backslash -ax}$ your objection on the score of extra expense would still apply?

There is not really any such difficulty as you suggest in representing a fraction like $\frac{Im - L\omega}{Im + L\omega}$ in a single line if brackets be used. It should be written $(Im - L\omega)/(Im + L\omega)$ just as the product of the same quantities must be represented by $(Im - L\omega)(Im + L\omega)$ and not by $Im - L\omega \,.\, Im + L\omega$. To insert these brackets is not really any alteration of the author's copy. In a fraction the numerator and denominator are each, in effect, bracketed by the line between them. If you bring up the denominator and abolish this line you must bracket the numerator and denominator respectively in some other way.—Yours, &c., Chas. T. Mitchell.

P.S.—As I am writing, I ought, perhaps, to say, that the line bracket over the exponent, $-ax$, should have been inserted in the fifth and not in the fourth line of my previous letter.

Toynbee Hall Electrical Society.—On Wednesday last the work of this Society was inaugurated at a social meeting held in Toynbee Hall. Amongst the speakers was Mr. W. H. Preece, who said he would do all in his power to further the scheme, which aimed at giving facilities for practical men in various branches of the electrical industry meeting together and exchanging ideas, both by means of reading Papers and experimental work. The Committee have some apparatus, but are appealing to the City Guilds and others for grants of money and further apparatus.

* Since this article was written it has been pointed out by Prof. B. F. Thomas (in the Paper already cited), that in the case of lamps exhausted without the aid of mercury, the age-coating is scarcely perceptible.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—Our readers are reminded that the tenders for the electric lighting of the Belfast Central Hotel are to be in by Tuesday next, the 25th inst.

——— The Glasgow Police Commissioners invite tenders for the supply of lanterns for electric lighting. Particulars of Mr. R. Hamilton, 52, College-street, and tenders to Mr. J. Lang, clerk to the Commissioners, by the 31st inst.

TENDERS ACCEPTED.—The Electrical Power Storage Company (Limited) have secured the contract for supplying the storage batteries for the St. James's and Pall Mall Electric Light Company's new station in Carnaby-street.

——— We understand that the Electric Lighting Committee of the Derby Corporation have accepted the following tenders for the building of the new electric lighting station, and for the engines, dynamos, &c. :—For the building, Messrs. Walkerdine and Co., £3,870. 4s. 3d. (engineers' estimate, £5,600); for the engines and dynamos, Messrs. Siemens Bros. and Co. (Limited), London, £10,781 (engineers' estimate, £10,500). The engineers are Sir Frederick Bramwell and Mr. Harris.

——— Messrs. W. T. Henley's Telegraph Works Company (Limited) have secured the contract for the supply of arc lights and cables for the Glasgow Corporation.

——— The contracts for lighting the Galatz and Kraila harbours at Bucharest have been placed with Messrs. Siemens and Halske.

SALE BY AUCTION.—Our advertisement columns contain particulars of the sale by auction, by Messrs. Bullock and Sadler, on Wednesday, November 2nd, of the stock-in-trade and plant of an electrical engineer at Brighton, comprising a 4-H.P. Robey steam-engine, a 2½-H.P. gas-engine, three dynamos, switchboard, 30 E.P.S. accumulators, a complete portable electric lighting plant, arc and incandescent lamps, batteries, &c., &c.

STEAM POWER.—Our advertisement columns contain particulars of extensive workshops with all necessary steam-power, &c., for electrical or experimental work, which are to let in the north-east district of London.

MESSRS. SHARP AND KENT.—We are informed that Mr. E. Jesse Piper has become a member of this firm, which will, however, be continued under the same name as previously.

MESSRS. VERITY AND SONS.—Owing to the growth of their electrical engineering business in the Birmingham district, this firm have taken offices at 116, New-street, Birmingham, above their large show-rooms. Orders for goods manufactured by the firm should be addressed to the Works, at Aston, Birmingham.

HOUSES OF PARLIAMENT.—Our contemporary, *Industries*, which was the first, some two years ago, to publish an elaborate and profusely illustrated technical description of the Forth Bridge, is now preparing a comprehensive description of the heating, lighting, ventilating, and sewage appointments of the Houses of Parliament, for a special number, which will be published on the 28th inst.

ELECTRIC TRACTION.—In the *Glasgow Herald* there is appearing from time to time a series of articles treating of new lines and new systems of electric traction. The last article appeared in the issue for October 14th.

DREDGER LIGHTING.—Messrs. Fleming and Ferguson, ship builders and engineers on the river Cart, Paisley, are completing the equipment of a powerful twin-screw steam hopper dredger for the Clyde Navigation Trustees. The vessel is to have a complete electric lighting outfit, which will include five 2,000 c.p. arc lamps for signal purposes and a number of glow lamps for the engine-rooms, &c. We hope they may succeed in this most troublesome task, as the vibration upon a steam dredger offers serious difficulties for both arc and glow lamps.

MILL LIGHTING.—It has been decided to considerably extend the electric light installation at Owen o'Cork Mill, Belfast, which already consists of 500 16 c.p. lamps.

ELECTRO-HARMONIC SOCIETY.—A smoking concert is announced for next Friday, the 28th inst., at the St. James's Hall Restaurant, W., at 8 o'clock.

TAXATION OF MACHINERY.—It is satisfactory to learn that in a case recently heard at the Durham Quarter Sessions the proprietors of the Ford Paper Works, whose assessment had been increased by £450, were successful on appeal, by which their assessment was reduced to the extent of £400, the Sunderland Union having to pay all costs. The result of the action should encourage users of machinery to resist unfair assessments whenever opportunity offers.

"THE IRONMONGERS' CHRONICLE."—A new monthly journal with this title has just made its appearance, and is intended to cater for the ironmongery, metal, iron, machinery, and allied trades. The annual subscription is 5s., and it is published at 139 and 140, Fleet-street, London, E.C.

MR. F. H. WHIPPLE.—The *Western Electrician* is responsible for the statement that Mr. F. H. Whipple, who is known in this country in connection with "Whipple's Reports" and "Whipple's Directory," has been arrested on a charge of obtaining money under false pretences.

DISSOLUTION OF PARTNERSHIP.—Messrs. Wynne and Barnard, electrical engineers, of 72, Grey-street, Newcastle-on-Tyne, have dissolved partnership; debts will be paid by Mr. W. R. Wynne.

BELFAST.—The *Belfast Evening Telegraph* of Friday last contains particulars of a report submitted to a Committee of the Belfast Corporation, which has had under consideration the question of the purchase of tramways and gas extension, and the introduction of the electric light. This Committee recommended that a Bill should be promoted in Parliament for the above purposes. With respect to the electric light, the Committee recommended that no undue haste should be taken to select any particular system, but (as stated in *The Electrician* of September 30th last) that the time had arrived when a 10,000-light installation capable of future extension should be undertaken, and they recommended that the services of an expert electrician should be obtained to advise as to the best method of procedure. The extension of the gas works was also recommended. The Committee's report has been adopted by the Corporation.

BLOCKLEY.—Some time back the village of Blockley was lit with the electric light, and at a meeting held lately it was decided to reinstal the light at an early date.

BRIDGEND.—The Local Board are taking steps to secure the introduction of the electric light on the lines of the installation at Lynmouth. Water is to be the chief motive power.——At a special meeting of the Board Mr. Morgan Williams was instructed to advise the Board with regard to the proposed lighting scheme, the Lighting Committee having recently visited Linton and other places for the purpose of obtaining data.

BRISTOL.—The Electric Lighting Committee of the Town Council have, subject to certain conditions as to the time when the work is to be finished, accepted the tender of Mr. C. A. Hayes for the erection of the central station building. The amount of the tender, which, it was stated, was not the lowest, is rather over £13,000. Mr. H. Faraday Proctor has been appointed resident electrical engineer to superintend the installation. The plans for the Central station were prepared by Mr. H. Williams, architect to the Committee, and the building is expected to be completed about July next.

DERRY.—At their meeting last week the Derry Corporation decided to put the provisions of their Electric Lighting Order into force, and for this purpose agreed to expend £12,500 for carrying the resolution into effect. The scheme they have under consideration is for the entire lighting of the City, and from the estimate prepared the Council calculate that a profit of £200 a year will result, in addition to a sufficient sum to provide a sinking fund to pay off the principal of the loan. The installation is to be proceeded forthwith on the lines of that adopted by the St. Pancras Vestry, London.

DUNDEE.—In connection with the installation of the electric light in this City, the Lighting Committee of the Police Commission have agreed to erect four additional 1,000 c.p. lamps in the High-street, at an initial cost of £100 and an estimated additional annual charge of £100.

GLASGOW.—Messrs. Mavor and Coulson are installing the electric light at the extensive premises of the National Telephone Company, including offices, the new exchange switch-room, stores, workshops, &c. This will render the National Telephone Company independent of the Corporation supply.

HACKNEY.—A special committee of the Hackney District Board of Works have issued their report, and in consequence the Board have decided to apply for a Provisional Order.

HAMMERSMITH.—The Electric Lighting Committee have scheduled the thoroughfares through which the Vestry are to lay distributing mains within a period of two years from the commencement of the Provisional Order. The following is the list of thoroughfares:—King-street, from Broadway to Ravenscourt-park; Broadway; Hammersmith-road, from Broadway to St. Paul's School; Queen-street, from Broadway to further side of St. Paul's Church; Brook Green-road; Shepherd's Bush-road; across Shepherd's Bush Green to corner of Wood-lane; Goldhawk-road to Starch Green Pond; and Uxbridge-road to the corner of Percy-road.

HAWICK.—In reference to the Note appearing in our last issue, we are requested by Messrs. Mavor and Coulson to state that the sum of £820 is the annual cost of lighting of street lamps, and not, as the Note seemed to indicate, the prime cost of the scheme.

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NEPAL, INDIA.—An installation of the electric light of considerable extent has just been completed in the palace of His Highness the Maharajah Beer Schumshere, Prime Minister of Nepal. The installation consists of 250 16 c.p. incandescence and 10 300 c.p. incandescence lamps, and a 40,000 c.p. search light, the latter of which is capable of throwing out sufficient light to illuminate the whole of the valley in which the palace is situated. The Calcutta, India Rubber, Gutta Percha and Telegraph Works Company have installed the light under the supervision of Mr. Lester Betts.

NOTTINGHAM.—The Electric Lighting Committee of the Nottingham Corporation have been busily engaged considering the old question of the public lighting of the borough. It is expected that their report will be presented to the Town Council shortly.

QUEENSFERRY.—At their last meeting the Town Council had under consideration the question of installing the electric light in lieu of gas, by which the town is now lighted, and after discussion the matter was remitted to a Committee, with power to employ an expert to report upon the cost. The Town Council have considerable water power at their command.

RICHMOND (SURREY).—The Electric Lighting Committee of the Local Board have reported on the negotiations between their representative and those of Messrs. Latimer Clark, Muirhead, and Co., and the plans for the proposed new buildings have now been approved. The work will be proceeded with immediately.

ST. PANCRAS.—In reference to the supply of Brockie-Pell arc lamps for the extension of the lighting of St. Pancras, for which we have previously intimated that the tender of Messrs. Johnson and Phillips had been accepted, the amount of the tender was £1,496. 11s. 8d.

SHOREDITCH (LONDON, N.E.).—Dr. H. Mansfield Robinson, solicitor and vestry clerk, has recently presented to this Vestry an exhaustive report in reference to the electric lighting of the district.

COMPANIES' MEETINGS & REPORTS.

The Brazilian Submarine Telegraph Company (Limited).

The 38th ordinary general meeting of the shareholders of the Brazilian Submarine Telegraph Company (Limited) was held at Winchester House, Old Broad-street, London, on Wednesday, Sir James Anderson in the chair.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting, and the minutes of the last meeting which were signed as correct.

The report was taken as read.

The CHAIRMAN: I will, as usual, make such remarks as appear to me appropriate, and I need only refer to some of the leading points in the accounts to begin with, and then go on to say, with prudence, I hope, what is in my mind with reference to the competition in which we are engaged, and upon which so much of our future prospects depends. The leading points in our report and accounts are as follows:—There is a decrease in revenue of £15,216 as compared with the preceding half-year, mainly due to the low rate of exchange. This, I am glad to say, is improving. We have spared no effort to raise our charge of currency to meet this loss upon our sterling receipts, and we are continuing to work to this end, apparently, I am glad to say, with some hopeful result. There is a decrease, however, of £47,035 in our revenue as compared with the corresponding half year of 1891, but the revenue of that half-year was abnormally large, due to the disturbed state of affairs in several of the South American Republics, which we had no right to expect would be continuous, and we had no right to hope that it would be so. The total expenditure is £2,929 less than in the previous half-year. The repairs of cables cost less by £9,633, but we were compelled to increase our staff for the working of our duplex system, and necessarily we had to increase the accommodation for that staff, as there are no houses at St. Vincent. We had also to erect tanks for our spare cable, and to extend our office accommodation at a cost for this half-year of £1,150. Then there was the cost of applying duplex to No. 2 cable, £3,000 of this cost falling due in the half-year under review, but this cost will now be reduced to £500 for each half-year for the next six years. I may inform you that the duplex has been of immense value to our working. Working both ways is a great benefit, and we can, when we think proper, work both ways on the next cable also. This brings the total decrease of expenditure to £2,929. With your permission I shall not refer to all the items of increases and decreases in the balance-sheet unless you desire it. Of course I have them all before me. Let me now refer to such criticisms as have come to hand from three of our proprietors. Out of 2,900 shareholders we have had three letters. Naturally, we receive such criticisms with all respect, and we consider among ourselves whether our policy can be defended upon business principles in the best interests of the proprietors, the efficient maintenance of the property, and the security, so far as it is possible, of our revenue for the purposes of dividends. For several years I have warned you that something like a crisis was coming, and now, at this moment, we are face to face with a rivalry which will test the wisdom of the policy of this Board since the formation of the Company 19 years ago. One honourable proprietor is of opinion that we ought not to make extensions out of revenue, but add all to capital, and that all such expenditure as can be properly debited to capital account should be so treated. Of course, as a matter of book-keeping there is much to be said in support of such a contention, but if such a policy were adopted in practice, then farewell to quarterly dividends; and when, in the course of time, a large expenditure of capital became imperative, it could only be got upon such onerous terms as would postpone or destroy all prospect of any dividends upon our ordinary stock, whereas, with a large reserve, such as we now have, and with a moderate amount of debentures, we could at once lay another cable if we desired to do so. We are in this position: our revenue-earning capacity is secure, even though a tariff war should be forced upon us. We shall not willingly initiate it, but we are directly threatened with it, both on the West and on the East Coasts. A reduced tariff, however, would no doubt increase the traffic, and besides being in a position to carry it better than any other Company, if the fight were too hard, we have the interest of our reserve to fall back upon for dividend purposes, if need be, as supplementary to our income from traffic. I hope you are observing that point. We are not exactly on our backs if we have a great opposition, for we have this reserve of interest to fall back on, and we should not have to go without a dividend, even though we dipped into the reserve. We are not so weak, therefore, as our opponents think—at least I believe so. Your Directors have always followed the principle of keeping the capital down, satisfied if they can pay a fair dividend, and keep a strong reserve. The other honourable proprietors who have written to us are of opinion that we ought to pay a larger bonus, and they tell us what we are very conscious of—that the sum carried to reserve is large in proportion to the dividend. That is very true, but we have a property liable to attack, and which is being attacked at the present moment, and in a manner which seems to leave no alternative short of a war of tariffs. It looks like that at the present moment, but a great deal may happen between just now and by-and-by. We are warned by our rival on the West Coast that if we do something—which we certainly shall do and must do—he will reduce the rates, but we are not without resources to meet that threat if it is to be put into practice. He has, so far, lowered the tariff, and so have we. On a previous occasion I told you we had reduced our tariffs by 33 per cent. and 50 per cent., and we can go as low as any Company can, and not be altogether without a dividend. I think I told you at our last meeting who our rival is. He has a cable from Galveston to Valparaiso. A few years ago this Company worked in harmony with a Company called the West Coast of America Company, going from Lima and Callao to Iquique, Arica, and the ports down to Valparaiso. For some reason not known to me yet this gentleman disregarded his partners and carried his cable down to Valparaiso, leaving the West Coast Company's cable out in the cold. It so happened that the Globe Company was largely interested in this cable, and they did not see, and do not yet see, why that cable should be ruined, and they do not intend that it shall be. In order to protect that cable a Company has been formed to lay a land line across the Andes from Buenos Ayres to Valparaiso to connect the West Coast of America cable with the East Coast cables, so we shall have in a few months' time cable communication all the way from London to Lima, from Peru to England and Europe, and our friend threatens us, as I understand, that if we do not let it alone he will do something very dreadful and come and attack us on the East Coast, as he has done for years. We are making this line, however, across the Andes. It is three parts made already, and do what he will we shall fight for it, and we shall then see what happens. Then there is the Company on the East Coast—from Senegambia to Pernambuco. That cable has been making for the last two years, and is now opened or about to be opened for traffic. The promoters sought to raise money by the avowed and published statement that they would take £80,000 per annum from this Company or the joint-purse Companies; and they opened their cable at a tariff 4d. per word lower than the tariff agreed upon—as fixed and tabulated by the Paris Conference as the obligatory tariff by every route for extra-European traffic. I will explain that. The Telegraph Convention, which meets every five years, have agreed that all traffics transitting any part of Europe is a certain traffic, and that no Company should come in and have a lower tariff, the object of the Convention being to create as many routes as possible for telegraphic communication at equal rates—not opposition rates. That is called the European *régime*. For extra-European traffic there is a higher tariff charged over the land lines transitting Europe, because they say—and properly say—if we have to maintain land lines all through Europe, Russia, Italy, and those great distances, and have to maintain them for extra-European traffic, necessarily, as there is nothing else going over those lines, we must have a larger tariff. There is, therefore, a European *régime* and an extra-European *régime*, and the Convention say that these two tariffs should be common to all comers, but no one is to come in and oppose us and the European Powers by some accidental line got up for promoting purposes. Therefore we are leagued together at this Conference to establish a tariff to all comers. It seemed strange to us that a private company, in disregard of inflicting loss upon every European state and upon the cable companies more especially, should, without any attempt to negotiate, rush before the public with a reduced tariff for no reason in the world but to force us to make terms that would give a value to their property which it does not now possess, as it is, so to say, a fifth wheel to a coach. Now, gentlemen, I did not wish to say so much even about that cable, but it is due to you that I should say something about a rival that has just come into the field. Its promoters, who are also its proprietors, are not allowed to carry their traffic lower than the Convention rates; but they are, I am told, carrying Press traffic free—or they were doing so two days ago. They are, as they say, determined to worry us into terms which they hope will enhance the value of their speculative cable. All I say just now is that we shall see. They pretend friendliness—and personally we are all friends; but they leave no

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stone unturned to injure us, and it is possible they may tire of carrying even Press messages for nothing. At all events, it does not frighten us. Then there is the Antilles cable, which is owned by a French company, and which goes from Cuba down to Vizeu (Para). They hope to get a Concession from Portugal to go to the Azores. That was given to us, but by some superior diplomatic action it was taken from us. As I have said, this French Company are now trying to get in, and if they can obtain from France a subsidy of £80,000 per annum, they propose to carry that cable and join it on to the Antilles cable. I do not know that France is very much inclined to pay this £80,000, and at all events they have not got it yet. You will observe, from what I have now said, that it is a very costly fight that is now going on, but I venture to believe that you will approve our policy of paying a moderate dividend, and making a strong reserve equal to a system of offence or defence. We are carrying messages from Buenos Ayres to England within the hour (applause), and from Pernambuco and Rio Janeiro within the half hour. Commerce cannot want greater facilities than that, unless it be that we shall carry telegrams free, and that we cannot do. We are just now in a position as if a merchant in London had his foreign correspondent in the same building, and they carried on their inter-communication by what someone has called a whispering gallery. There is no system of international telegraphy which can beat us. I do not know what science has yet in store for us, but so far we do not know that there is anything looming in the distance that can excel what we are now doing, and we can adopt anything that may be proved to be better or faster. Our cables are duplicated and duplexed, our speed of transmission cannot be excelled, and we have a substantial reserve, which enables us to look our rivals in the face, and we certainly need not be under any feeling of panic or alarm. That is the position we are in, and in my opinion it is a very sound one. We have laboured at it all along for 19 years, steadily pursuing the policy of building up a reserve fund, and warning you from time to time—I have told you frequently—that this was our backbone, and that while we were paying a good dividend you must be satisfied to let the Directors take from revenue what you can spare to strengthen our position. I look forward to this, that with our reserve fund, that if we were in a tight fight we could do two things: we could take the interest on the reserve fund and put it to the reserve, and not add any more to that fund; or we could take it for increasing your dividend, plus any dividend arising from revenue from the traffic. I, therefore, do not address you in a pessimistic spirit or in a despairing tone, for I think we are in a good sound position. If any shareholder desires to ask any question I will do my best to answer him. Meantime I propose the following resolution:—

"That the report of the Directors and the accounts to June 30, 1892, now submitted be approved and adopted, and that a dividend be now declared of 3s. per share (making, with the interim dividends already paid, a total dividend of 6 per cent. for the year ended June 30, 1892) and also a bonus of 1s. per share in respect of the profits for the year ended June 30, 1892, the said dividend and bonus to be respectively free of income-tax."

I may add, in a word, that that is for the period ended June 30th. From that time to now we are still doing very well.

Mr. FREDERICK YOULE seconded the motion.

Dr. H. ELLERY TREWHELLA said he thought that the policy of a large reserve fund was an exceedingly wise one, and he was glad to find that the Directors still intended to continue that policy. He thought it possible, however—without wishing to call into question the Directors' policy—that, instead of increasing the reserve fund by £80,000 or £90,000 a year, they might see their way to putting to it £10,000 or £20,000 a year less.

The CHAIRMAN said he quite agreed with what Dr. Trewhella had said, but he would not like to pledge the Directors to anything at the present moment.

The resolution was then carried unanimously.

On the motion of the CHAIRMAN, seconded by Lord SACKVILLE A. CECIL, Sir Henry D. Gooch, Bart., was re-elected to his seat at the Board, as was also the Duke de Loulé, on the motion of the CHAIRMAN, seconded by Mr. J. DENISON PENDER.

The Rev. N. WILLIS then proposed the re-election of the auditors, Mr. Henry Dever and Mr. John Gane.

Mr. W. C. WEST seconded the motion, which was adopted.

Mr. W. GRIFFITH congratulated the shareholders on having such able statesmenlike men at the head of the Company's affairs, and said he was sure that their policy commended itself to the proprietors at large. The fact that their system was duplicated might render unnecessary the building up of their reserve fund much larger, but the shareholders must remember just now that the clouds were gathering somewhat. It was therefore well to be prepared, more especially as whatever was put to the reserve fund would make their dividend more secure. He concluded by moving a vote of thanks to the Chairman and Directors.

Dr. TREWHELLA seconded the motion, which was unanimously carried.

The CHAIRMAN having acknowledged the vote, said: Lord Sackville Cecil reminds me that there is one point which I have not mentioned, namely, that one of our cables is 20 years old. We are, however, repairing cables older than that, and I am not frightened; but still, everything points to the necessity of a strong reserve. Do not ask us, therefore, to "back down" on that any more than we are willing, but we understand the desirability as much as you can of doing so whenever we are able to.

On the motion of Dr. TREWHELLA, seconded by Mr. J. T. PRATT, a resolution was passed recognising the zealous services of the staff at home and abroad.

The CHAIRMAN said that it would give him much pleasure to let the staff know of the appreciation in which their services were held by the shareholders.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

BIRMINGHAM IRON AND STEEL STAMPING COMPANY (LIMITED).—A Company has been registered under this title with a capital of £3,000 in £1 shares, to acquire, take over as a going concern, and carry on the business of iron and steel stampers, electric light fitting manufacturers, iron founders, mechanical and electrical engineers, carried on under the style of "The Birmingham Iron and Steel Stamping Company," at Aston-lane, Aston, Birmingham, and to enter into an agreement with Mr. O. Ward, of Acock's Green, Worcestershire.

ELIESON ACCUMULATOR BRITISH PATENT SYNDICATE (LIMITED).—This Company was registered on October 13th, with a capital of £12,000 in £1 shares. The objects are: To acquire from Mr. Chaimsonovitz P. Elieson the exclusive rights for Great Britain and Ireland in his patent for electric accumulators, No. 7,697 of May, 1891, with a view to enter into and carry into effect an agreement, particulars of which are not given, and to carry on the business of manufacturers of, and dealers in, electric storage batteries, electric locomotive engines, electric tram engines, dynamo-electric machines, torpedo boats, dynamos, and every description of apparatus required for or capable of being used in connection with the generation, distribution, supply, accumulation and utilisation of electricity. The subscribers are:

	Shares.
Richard R. Hutchinson, Pear Tree House, Fulham-road, South Kensington, electrical engineer	1
Watson Smith, 6, Great Winchester-street, E.C.	1
Frederick C. Smith, 6, Great Winchester-street, E.C.	1
Edward Spendlove, 33, Southfield-road, Wandsworth, S.W.	1
Stanley W. Smith, 6, Great Winchester-street, E.C.	1
Graham S. Ridley, 6, Great Winchester-street, E.C.	1
H. Arthur Davies, 3, Platt's-lane, Hampstead, N.W.	1

The number of Directors is not to be less than three nor more than seven, the first being the above signatories. Qualification (other than that of a subscriber), £500.

NEW ZEALAND ELECTRICAL SYNDICATE (LIMITED).—An agreement dated September 22nd, between this Company of the one part and the Gülcher (New) Electric Light and Power Company (Limited) of the other part, states that on December 24, 1890, the New Zealand Syndicate and the Gülcher Company agreed that as soon as the Syndicate was clothed with the necessary statutory powers for supplying electricity or electrical energy for private installations and use in the City of Wellington, New Zealand, the Gülcher Company would sell to the Syndicate all its rights in and under a certain contract, dated August 3, 1888, together with the lands, buildings, stores, machinery, and plant of the Gülcher Company in Wellington for £20,000, to be fully satisfied by the allotment of 2,000 fully paid up £10 shares in the Syndicate, and that these necessary powers having been obtained it was agreed that the Syndicate should issue the 2,000 shares, numbered 1,001 to 3,000 inclusive. The Company was registered on December 20, 1890, with a capital of £30,000, in £10 shares, to supply electricity in New Zealand, Victoria, New South Wales, North, South, or Western Australia, Tasmania, New Guinea, the Fiji Islands, and elsewhere in Australasia. The last return shows that 955 shares have been taken up, and £1,000 paid in respect of such shares.

NORTHERN COUNTIES ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The name of this Company is to be struck off the register unless information respecting its position is shortly forthcoming. The last return was filed November 17, 1890.

VEALE AND CO. (LIMITED).—The statutory return of this Company, made up to October 5th, has been filed. The Company was registered on May 26th last with a capital of £10,000, in £1 shares. At the time of making up 4,904 shares had been taken up, of which 3,644 had been considered as fully paid. Upon the remaining 1,260 shares the full amounts had been called, resulting in the payment of £1,235, and leaving £25 in arrears.

CITY NOTES, &c.

BERLINER ELEKTRICITATSWERKE.—A dividend of 7¾ per cent. has been declared on the past year's working.

CALLENDER'S BITUMEN, TELEGRAPH AND WATERPROOF COMPANY (LIMITED).—The directors of this Company have declared an interim dividend at the rate of 8 per cent. per annum on the capital of the Company, payable on November 1st next.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 16th were £902, as against £794 for the corresponding period of last year, being an increase of £108. The total receipts for half-year amount to £12,518, against £11,415 in the corresponding period of 1891, being an increase of £1,103.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment by warrants on November 1st next of interest for the half-year ending October 31st, on their Four per Cent. Mortgage Debenture Stock. The transfer books will be closed from October 27th to November 1st, both days inclusive.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—There has been a recovery in the price of the shares of this Corporation during the past two or three days, as will be seen from the share list. The rise represents an advance of 1 over last week's prices.

NEW AUSTRALIAN ELECTRIC COMPANY (LIMITED).—At the half-yearly meeting held at Melbourne on August 29th, the Chairman, Prof. Kernot, said that the electric light was making great headway in Mel-

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bourne—in fact, the demand for the light was more than they could supply with their present capital, which he hoped they would be able to increase.

PETROLEUM ENGINE COMPANY (LIMITED).—The Directors recommend the declaration of a dividend on the 18,754 shares in the Company at the rate of 1s. per share, free of income tax, for the year ended June 30th last, leaving a balance of £236 to be carried forward. The shareholders meeting, held at Winchester House on Wednesday, was private.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—A private meeting of the holders of founders' shares in this Company was held on Tuesday last at Winchester House, E.C.——The electric current sold by this Company for the quarter ended September 30th amounted to £5,763, as against £5,279 for the corresponding period of last year.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the fortnight ended Oct. 15, 1892, were £2,470, compared with £1,492 for 1891, showing an increase of £978.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Oct. 14, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,611.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 12.	Price Wednesday, Oct. 19.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 19. Highest.	Lowest.
			TELEGRAPHS			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American xd	50 51	49½ 50½	5 6 11	Jan., Apr., July, Oct.	50½	49½
£2,876,140	Stock	25/0	Do. Preferred xd	91 92	89½ 90½	5 18 2	" "	91½	89½
£2,876,140	Stock	5/0	Do. Deferred	10¾ 11¼	11 11⅛	..	" "	11⅛	11⅛
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¾ 11	11¼ 11¾	5 19 2	Mar., June, Oct., Dec.	11⅛	11⅛
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	101½	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	168 173	168 173	4 0 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17½ 18½	17½ 18½	5 8 1	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	3¼ 3⅝	3¼ 3⅝	4 16 9	April and October..	3⅛	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States xd	11⅞ 12⅛	11¾ 12	5 16 8	Jan., Apr., July, Oct.	12⅛	11⅞
400,000	10	2/6	Eastern xd	15 15½	15 15½	4 5 3	" "	15½	15
70,000	10	6%	Do. 6 per Cent. Preference xd	15½ 16	15½ 16	3 15 0	" "	..	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111 114	112 115	3 9 7	May and November	114½	112
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	106 109	107 110	4 10 11	February & August	108¾	..
250,000	10	2/6	Eastern Extension xd	15⅜ 15⅝	15⅜ 15⅝	4 9 7	Jan., Apr., July, Oct.	15⅝	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	109 112	109 112	3 11 5	February & August	111½	110
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103 106	103 106	3 15 6	February & August	..	..
180,227	10	1/0	Globe Telegraph and Trust xd	10½ 10¾	10⅜ 10⅝	4 11 9	Jan., Apr., July, Oct.	10⅝	10⅜
180,042	10	6%	Do. 6 per Cent. Preference xd	15⅜ 15⅝	15⅜ 15⅝	3 16 10	" "	15⅝	15½
150,000	10	5/0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	18½	18⅛
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	106½	..
17,000	25	37/6	Indo-European	43 45	43 45	5 11 1	May and November	43½	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
10,802	8	4/0	Reuter's xd	7 8	7 8	5 0 0	April and October..	..	..
3,381	£100 Cert.	*	Submarine Cables Trust 6%	116 121	118 122	4 18 4	" "	119½	118
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	3½	..
£150,000	100	8%	Do. Debentures 8% 1902	103 107	103 107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama	1½ 1⅝	1½ 1⅝	..	" "	1⅝	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10	9⅞ 10⅛	5 17 1	May and November	10	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½ 9½	8½ 9⅛	6 6 4	" "	9½	8½
64,242	15	6/0	Western and Brazilian	8½ 9	9 9⅛	6 6 6	" "	9⅛	9
33,129	7½	1/8	Do 5 per Cent. Cumulative Preferred	6 6½	6⅛ 6⅝	5 11 1	" "	6⅞	6½
33,129	7½	4/6	Do. 5 per Cent. Deferred	2½ 3	2⅞ 3⅛	..	" "	3	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	104 107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	104 107	5 12 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123 128	123 128	5 9 5	May and November	..	—
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	—
			TELEPHONES.						
40,000	£5	10/0	Chili Telephone	..	3 4	3 4 0	..	3½	..
22,500	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅜ ⅝	⅜ ⅝	6 10 10	May and November	⅝	½
220,000	£1	4½d.	Oriental (11s. paid)	1⅛ 1⅜	1⅛ 1⅜	7 18 2	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅞ 5	6 0 0	June and December	5	4⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13⅜ 14½	14 14½	4 2 9	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13½ 14	13½ 14	4 5 9	" "	13⅜	13⅜
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	111 113	111 113	3 19 8	January and July ..	112⅜	111⅛
48,000	£10	..	New Telephone, Limited (£2 paid)	1½ 2	1⅞ 2	..	..	1⅛	1⅛
58,000	5	1/0	United River Plate	1⅞ 2⅛	2⅛ 2⅜	..	January and July .	2⅛	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	90 100	5 0 0	—	90	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	—	City of London Electric Lighting (fully paid)	10½ 10¾	10⅞ 11⅛	..	—	11⅛	10⅞
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	..	..	..	—	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	—	..	..
8,332	£5	..	House to House Electric	..	..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	5⅛ 5⅜	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5 4 4	January and July ..	..	..
30,000	£5	4½% '91	Liverpool Electric Supply (£3 10s. paid)	3 1/16 3 2/16	3 1/16 3 2/16	3 15 9	March	..	..
10,000	£5	4½% '91	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	4 6 9	March	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	—	—	—
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7	6½ 7	..		..	..
£50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	103 105	104 107	4 15 3	June and December	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½ 5½	4½ 5½	—	—	..	..
18,680	£5	2/6	St. James' and Pall Mall	7⅞ 8⅛	7⅞ 8	—	—	8	7⅞
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	—	—	..	..
42,853	5	3%	Westminster Electric Supply (fully paid)	5⅜ 6¼	5½ 6	2 10 0	—	5⅝	5⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1 9/32	Brush Electrical Engineering xd	3 3½	3 3½	..	..	3 3/16	3⅛
69,996	2	6%	Do. 6 per Cent. Preference xd	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2 1/16	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5 5⅛	5 5⅛	6 7 3	January and July ..	5¼	..
12,139	5	17%	Edison and Swan United	..	..	..	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	..	.	..	..
45,000	10	12/0	Electric Construction	3¾ 4¼	4⅛ 5	..	—	4⅜	4 1/16
70,000	2	10/0	Elmore's Patent Copper Depositing	2 2¼	2 2¼	—	—	2 1/16	2
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha & c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	21
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/9 4/3	1/16 ¼	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3½ 4	3½ 4	9 12 6	May and November	3⅝	3 11/16
37,350	12	12/0	Telegraph Construction and Maintenance	44 46	44 46	5 4 4	March and July.....	45½	44½
150,000	100	6%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..	..	..	..	..	..
—	£5	8%	Do. Preference (fully paid)	..	..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
50,000	£10	½%	City and South London Railway	2⅛ 3⅛	2⅛ 3⅛	1 8 6	..	..	..

* Ex 30s. on account of coupon Oct. 15, 1892.

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THE ELECTRICIAN:

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NOTES.

One of the most useful functions of the London Chamber of Commerce is to encourage, by various facilities, the concerted action of the members of its numerous sections, and to ascertain the intentions of those who are supposed to be interested in any particular matter. In the case of the introduction of the B.A. standard screw-thread, those who did not use it were surprised to find the extent to which it was employed at the time of the issuing of the circular (July, 1889); many who were then hesitating decided to adopt it, and though the Chamber of Commerce cannot be said to have introduced the idea, or to have thrust this screw gauge upon its members, the result of its efforts was practically the same. But to thus encourage a common movement it is essential that someone should make a start, and in the case of the Chicago Exhibition, a circular asking the members of the Electrical Trades' Section whether they intended to send exhibits received not a single reply. This result fully confirms the view which we have always taken of this matter. No doubt the General Electric Company and the Electric Construction Corporation will be worthily represented, and will show what other English manufacturers could have done had they cared to add to the attractions of the show.

In 1889 M. Victor Popp was the lucky recipient of an electric lighting concession covering a large portion of Paris, and inaugurated his now well-known system of dotting dynamos about in storage battery sub-stations, and obtaining the necessary motive power from his compressed air mains. Such a roundabout way of generating current for the lamps has kept the concern in a perennial state of financial difficulty. A short time since the compressed air and electric lighting enterprises were amalgamated, the German house which had financed them having got into difficulties and its liabilities having been taken over by the Disconto Gesellschaft of Berlin. As a result of this amalgamation and change of proprietors, a clean sweep has been made of the original management; and this step, calculated in any case to arouse French susceptibilities, having been taken with characteristic Teutonic *brusquerie*, seems likely to result in a revocation of the concession, a perfectly legal proceeding, since by its terms none but Frenchmen are allowed to work it. In case of siege the provisions for the Paris garrison would be stored in cold-air chambers, and the possible consequences of allowing a German concern to run this important system of cold storage cannot be contemplated by the authorities without a shiver.

The interesting article by Lieut. Bacon on Search-lights, which we print this week, reveals the fact that the use of projectors in naval warfare is very different to the demonstrations which are familiar to sightseers at exhibitions. The name "search-light" is indeed rather misleading, for groping about like a policeman with a bull's-eye lantern is by no means an efficient method of using these much-discussed weapons.

Our readers will be glad to notice that the progress made in connecting life-saving stations along the coast has already done something to justify the expectations of its promoters, and to warrant the establishment of a complete chain of electrical communication. Three different cases were reported, during the recent storms, of lifeboats having been summoned, or their assistance being expedited, by the use of the telephone, and resulting in the saving of several lives.

With a total mileage of wire amounting to over 739,000, and offices numbering nearly 21,000, the Western Union Telegraph Company may justly claim to be one of the biggest of America's big concerns. It may also be considered, financially speaking, one of the most successful. For although dividends have not increased they have been steadily maintained during the past four years, and the surplus has been augmented by about five million dollars. The figures which are furnished by our American correspondent this week seem to indicate, however, that this gigantic business has reached a point at which further development brings no proportionate increase of profit, the working expenses growing rather more rapidly than the receipts. Nevertheless, new offices continue to be opened at the rate of some 600 annually, a fact which speaks wonders for the prosperity of the country, and hardly less so for the enterprise of the Company.

Of two evils, namely, premature publication of the results of a research, followed by hasty criticism, and on the other hand, reticence which ends in publishing a big Paper before a big Society, or nothing, the former is, perhaps, the lesser. When, at last, an important investigation has been concluded, and perhaps years after the commencement of the work the Paper is in the hands of the scientific public, interest in what was subject of importance may have faded. By giving a preliminary notice appetite is whetted for more, undue criticism is disarmed, and a title to priority, the coveted reward of many an investigator, is firmly established. If contributions to science fell, as the gentle rain from Heaven, through-

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out the year, instead of in a deluge during the St. Swithin period of Societies' meetings on which we are now entering, mental digestion, to return to our former metaphor, would be more easy.

THE recent publication of some of the results of Profs. FLEMING and DEWAR'S investigations on the resistance of metals and alloys at low temperatures was an excellent example of the course which we advocate, and it has called forth some very interesting remarks by M. GUILLAUME of the French Standards Department. Some of his comments, which will be found in another column, may be answered by the further publication which is expected, and the others are in themselves of great interest. We ventured to append to our notice of these experiments diagrams plotted from the results. Since M. GUILLAUME has called attention to the apparent error at – 80°C., we may point out that this was very clearly shown in our diagrams on page 612 and 614 of *The Electrician* for the 7th inst. We hesitated, however, to allude to it at the time, since the investigations were confessedly incomplete; and on a former occasion, when we discovered a somewhat similar discrepancy, after plotting the results given in an abstract of a Royal Society Paper, by other authors, our desire for accuracy was not received with that philosophic calm which should adorn the scientific mind.

ON a recent occasion we referred to the use of electric locomotives in mines, and expressed surprise that they were not more frequently used, now that the trolley had become so general for tramway work. The General Electric Company of America are apparently fully alive to this class of mining work, and have already standardised electro-locomotives with draw-bar pulls varying from 750 to 4,500 pounds. The machines are designed to travel at from six to ten miles per hour. The overall dimensions for a 30in. gauge locomotive, with a 3,000 pound draw-bar pull, are 9ft. 6in. long, 4ft. wide, and 3ft. high; the wheel base is 3ft. 4in., and the total weight 15,000 pounds. These figures are very satisfactory, and promise a strong, compact and handy machine. The weight is, perhaps, the only difficulty, but it must be recollected that as soon as a dead load of one ton or so is exceeded it is necessary to use heavier rails, and to keep the track in better order than is usually the case for light haulage where the unit trucks average, perhaps, 15cwt. each.

THE design of the framing of this locomotive successfully meets many of the objections raised against the use of electricity for haulage underground. The frame consists of a single massive casting, box-shaped, with recesses for the axle-boxes. The motor is placed in the centre, between the two rolling axles, to each of which it is coupled by double-reduction tooth gearing. A space at one end forms the operating platform, and another at the other end makes a convenient place for the rheostat used in starting. The brake levers and the trolley are also attached to suitable parts of the framing. The body of the motor consists of two main castings, the lower forming the bottom pole-piece and carrying the bearings for the armature and the two intermediate shafts. The top pole piece is part of the upper field casting, which completely covers up the armature, field coil, and the other interior parts. The single exciting coil is wound around the top pole-piece. From a mechanical point of view the design is excellent, with the exception of the use of iron castings, which is always objectionable when a machine is subject to rough usage; but probably steel will shortly be employed instead.

IF chemists had known a little more of the fundamental principles of electricity, or electricians had concerned themselves with one of the prettiest applications of the special form of energy with which they are primarily concerned, an investigation now announced as depending upon a "new principle" would have had no ground for claiming to include any point of novelty, and the resources of the analyst would have long been enriched by a method of considerable utility. All chemists realising that there is a direct relation (obscured it may be in many cases, but clear enough in some, and indubitably existing in all) between the heat of combination of the constituents of an electrolyte, and the electromotive force needed for its electrolysis, have been aware that there is a fair prospect of founding methods of analytical separation on this fact.

ELECTROLYTIC analysis is, unfortunately, a cult confined to the comparatively few, largely because the necessary electrical supply is not in everyone's hand, and its immediate disciples have been somewhat apt to follow the rules laid down by their more noted companions, rather than seek new principles for themselves. Now, however, a German chemist, H. FREUDENBERG, following the announcement of LE BLANC that the point of decomposition of an electrolyte can be sharply determined, has endeavoured to effect the quantitative separation of various metals by submitting their solutions to electrolysis with a definite and constant voltage. As a practical outcome he has found that with a Leclanché cell giving 1·35 volts, silver can be separated from copper and bismuth, and mercury in the mercurous state from copper, bismuth and arsenic, the metals being in all cases in weak nitric acid solution. When the relation of volts to the deposition of a metal from its solution is a little more generally understood, we shall no longer see a distinguished chemist, as actually happened not very long ago, sorely puzzled to find that a single Daniell failed to throw down a trace of copper from a solution of copper sulphate when a platinum anode was used, but deposited it freely when one of copper was substituted.

Bradford.—The Town Council have decided to spend £30,000 on an extension of the electric lighting system.

Nelson.—On Saturday last the work of laying underground mains on the low-pressure system for the Corporation was commenced.

Brighton.—The Lighting Committee of the Town Council have adopted a scheme for lighting a great part of the King's-road and the sea front with the electric light.

Electricity in Newspaper Offices.—The Vienna *Fremdenblatt* is now being printed by electricity. Current is obtained from the mains of the International Electric Company.

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Barnet.—The Local Board have intimated their intention to apply for a Provisional Order authorising them to supply electricity for public and private purposes within their district.

New Books.—Messrs. E. and F. N. Spon will shortly issue "Household Electric Lighting," by Mr. A. Fahie. The book will be fully illustrated, and consist of about 150 large 8vo. pages.

Ischl.—The town of Ischl, in Upper Austria, is to be lighted by electricity. Water-power will be available. An electric tramway and the lighting of several adjacent places are included in the scheme.

Whitehaven.—It is understood that a letter has been received from the Local Government Board declining to sanction the borrowing of more than £14,000 for the purposes of electric lighting in this town.

Rouen.—According to *La Lumière Electrique* a fire broke out on the 26th ult. in Rouen Cathedral, due to a short circuit on some electric light leads causing a gaspipe to melt, with the result that a beam was fired.

Cambridge.—An accident occurred a day or two ago at the electric lighting works, now in course of construction, by the falling of a quantity of brickwork in the furnace room. Several workmen were more or less injured.

Galileo.—The University of Padua is about to hold a festival in honour of Galileo. The 7th of December, 1892, will be the tercentenary of the day upon which Galileo ascended the chair of mathematics at that University.

Toynbee Hall.—On Saturday last Prof. S. P. Thompson delivered a popular lecture at Toynbee Hall on "Magnetic Stresses," and showed a number of interesting experiments, which were much appreciated by an attentive audience.

The Edison Lamp Patent Decision.—Mr. Edison is reported to be much elated over the recent decision, and is stated to have said that he had always suspected that he was the inventor of the incandescent lamp, but now he was sure of it.

Portsmouth.—Yesterday afternoon the ceremony of laying the foundation of the municipal central lighting station took place, and was followed by a dinner. The scheme adopted by the Town Council has already been described in our columns.

Lancaster.—The Town Council have adopted a report of a sub-committee who, after visiting Bradford, Oxford, and London, recommended the adoption of the low-pressure system. Three companies have been invited to furnish the Corporation with a complete scheme, specifications, and estimates.

Australian Train Lighting.—The Railway Commissioners have recently entered into an agreement with the Brush Electrical Engineering Company to run for six months on the South Australian railways a train fitted with the electric light. The inaugural trip of the train was made last month.

Dundee.—At a recent meeting of the Gas Commission Committee the question of supplying the electric light outside the compulsory area was discussed. The Committee was informed that the Board of Trade had intimated that it could not sanction any expenditure for lighting outside the compulsory area.

Mason College Engineering Society.—The opening meeting of this Society for the session 1892-93 was held at the Mason College, Birmingham, on Wednesday, the 19th inst., when Prof. Robert H. Smith delivered his Presidential address on "Technical Education: Its Use and Abuse, What it Can Do, and What it Cannot Do."

Electric Traction in Brussels.—The Brussels Tramway Company and a suburban railway concern having asked permission to adopt the overhead trolley system of electric traction, committees were appointed by the Ministry of the Interior and the Railway Ministry to consider these applications. Both Committees have reported favourably.

Consolidation of Edison Interests in Canada.—The Edison Incandescent Light Company of Toronto is taking steps to acquire and consolidate under its control the various Edison electrical works in different parts of Ontario. It has purchased already the Edison General Electric Company of Hamilton and the Edison establishment at Peterboro', and will operate them in connection with its Toronto business.

Personal.—Mr. E. R. Dolby has been appointed by the Berkshire County Council to deliver a series of lectures upon "Steam Engines and other Prime Movers, with Special Reference to their use for Agricultural Purposes."——Mr. David Cook, who has for some months past fulfilled the duties of engineer as well as those of manager to the City of London Electric Lighting Company, has been formally appointed engineer and manager to the Company.

The Electric Staff.—According to the *Western Daily Mercury*, the up Cornish express, due at Plymouth at 1:59 p.m., on arrival at Saltash on Monday found its progress blocked, owing to the signalman being unable to withdraw the electric staff. Consequently, he had to telegraph to Devonport, whence a special pilot set out on foot. He was accompanied by an electrician, and on their arrival the staff was taken out. The train, after nearly an hour's delay, was then started on its journey. There were two or three Directors in the train.

Derry.—At a meeting of the Lighting Committee of the Corporation last week it was agreed that Mr. M'Clelland's offer of a site for the generating station should be accepted upon conditions, and Mr. Blake was instructed to prepare plans and specifications for the public lighting of the entire city. It was also ordered that the plans and specifications, when prepared, should be submitted to Dr. John Hopkinson for his opinion on the electrical portion of the scheme, and that a mechanical engineer should be appointed to give his opinion on the steam machinery.

Cables Interrupted.—

Cables.	When interrupted.
Bolama and Bissao (communication with) ...	Sept. 9, 1892
Cayenne-Vizeu...	Sept. 24, 1892
Jamaica-Colon	October 13, 1892
Para-Maranham.....	October 15, 1892
Hong Kong-Amoy.....	October 21, 1892*
Hong Kong-Foochow.....	October 21, 1892*

* Owing to these interruptions telegrams for Hong Kong, Macao, Canton and Manilla can only be sent *vid* India, and telegrams for Shanghai, Amoy, Foochow, and Japan can only be sent *vid* Wladiwostock.

Gilbertiana.—A lithograph facsimile edition of Gilbert's "De Magnete" has just been made in Germany, from the folio edition published in London in 1600. The publishers of this print are Messrs. Mayer and Müller, of Berlin. It is hopeless to expect a lithographic process to reproduce with any crispness the quaint old woodcuts of the original; but the work, such as it is, has been well done. In all known copies of the original folio there exist on page 11 two hand-made corrections of misprints in Greek words occurring in the text. These corrections have not been reproduced in the lithographic reprint.

Atmospheric Electricity.—For some months past M. Mascart has had, says *La Lumière Electrique*, some of his registering electrometers installed on the Eiffel Tower. He does not propose to obtain precise measurements at present, but is only endeavouring to find exactly what use can be made of the Tower for investigations in atmospheric electricity. Under present conditions the instruments are by no means favourably situated for observing the potential of the air; nevertheless, the values obtained are about ten times higher than those obtained at the Parc Saint Maur Observatory, a striking proof of the rapid growth of electric potential with elevation.

Electrical Coast Communication for Life-saving Purposes.—During the recent storm there were no less than three instances in which the telephone lines recently established along the coast proved of service. At Brancaster the lifeboat was called out by a telephone message from the coastguard at Thornham, and saved five lives. At Hunstanton the lifeboat crew were promptly assembled in response to a telephonic message, but the necessary assistance was given by another boat; while at Winterton the telephone was successfully used to secure the services of a tug from Yarmouth to tow out the lifeboat to assist a wreck on the Happisburgh Sands.

The Electrical Utilisation of the Niagara Falls.—Prof. Forbes is reported to have stated in the course of an interview with an American journalist that the dynamos for the Niagara scheme would be the largest that electricians had ever been called upon to design. The Company had signified its inten-

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tion of putting in dynamos capable of generating 10,000 H.P. each. These monster machines would be constructed entirely from new and original plans. He had received a large number of designs from prominent electricians, but had found none that completely satisfied him. He should probably construct the dynamos on plans of his own in which he had confidence.

Electrical Manufacturing Re-arrangements in France.—At a recent meeting of the Compagnie Electromécanique, which was formed in 1885 by the well-known engine-makers, MM. Weyher Richemond and MM. J. Belleville, and the cable-making firm of Menier, it was announced that the Compagnie Continentale Edison and the Société Heilmann-Brown had given their adhesion, and that the Société Générale des Téléphones would also do so. The object of the Compagnie Electromécanique seems to be to take over that portion of the business of each individual adhering firm which that firm finds some difficulty in carrying on itself. Thus the Compagnie continentale Edison proposes to transfer to the Compagnie Electromécanique all its dynamo-making business, devoting itself henceforth entirely to lamp-making.

An Engineering Tripos.—The discussion in the Senate of the University of Cambridge, of the proposal to found a mechanical sciences tripos for engineering students was, says *Nature*, unexpectedly favourable, in marked contrast to the reception accorded to former schemes. Prof. Ewing is to be congratulated on the skill with which the new plan has been framed, and the success with which he has met and conciliated the original opposition of the more mathematical members of the Senate. The grants for the approval of the plan have been sanctioned by the Council, and it is not likely that they will now be opposed. Some fifteen students are already at work in the engineering laboratory in preparation for the new tripos, which bids fair to take a good place among the honours schools, and cannot fail to stimulate the growth of the engineering department under its present energetic head.

Taunton.—The Directors of the Taunton Electric Lighting Company not finding Mr. Kapp's report to their liking, secured the services of Dr. Fleming, who is of opinion that the system of electric lighting now in operation is the one best adapted to the present requirements of the town; that the plant is in very fair condition, is of a thoroughly good type, and the general arrangements and site of the station have been made with all reasonable forethought for the future. Dr. Fleming also thinks that when the whole of the power available is taken up, and some small additions made, there is no reason to doubt that it will be capable of producing the full output of which it is capable at a cost which will leave a sufficient margin. Having regard to the state of the plant, its original total first cost, and the fact that the proposed purchase price includes the freehold of the land, Dr. Fleming does not consider that the proposed purchase price (£9,300) is an unreasonable figure. If the arc and incandescent lighting is extended to the whole of the streets of the town, and if custom outside by private consumers can be obtained, equal to a yearly demand of 100,000 units, Dr. Fleming thinks that electric lighting might become a source of profit to the ratepayers.

The Electrical Industry in Germany.—The following statistics with regard to the value of electrical goods manufactured in Germany and relating to the years 1890 and 1891 were recently given by the *Elektrotechnische Zeitschrift* on the authority of Herr Fr. Vogel. Telegraphic apparatus to the value of £76,000 was made, telephones over £80,000; railway signalling apparatus nearly £80,000; total, with electric bells, &c., about £400,000. During 1890-91 3,500 continuous current dynamos, alternators, and transformers were built each year, representing £320,000. In 1886 a large German firm built 350 machines, having a total output of 2½ million watts. Last year the same firm turned out 760 machines, the total output of which was 10 million watts, the average size of machine being, therefore, about 9½ H.P. and 17½ H.P. respectively. Accumulators are being turned out in Germany to the amount of £224,000 per annum. About 17,000 arc lamps are made every year, their value being £100,000. The arc light carbon turn-out amounts to nearly £80,000 per annum, whilst that of incandescent lamps totals up to £128,000. The value of the total annual electrical output of all sorts is placed at £1,320,000 or £1,360,000. The number of individuals employed in electrical factories is about 15,000.

Governing Water Wheels.—The sudden variations of load met with in electric tramway work are even more difficult to cope with in the case of turbines than in the case of steam engines. A "Mechanical Engineer" writes to the *Electrical Engineer* of New York, suggesting that the following device should be tried:—Construct a series-wound dynamo large enough to absorb the whole power of the water wheels without injury, and belt it to the main shaft. Build this dynamo so that its critical speed shall be reached when the main shaft runs a few turns above normal, and so that it shall not begin to build up its field until a few turns below it, using "teaser coils" on the fields if necessary. Make the dynamo waterproof, and put it in a tank of water, or put it in a tank of insulating oil, and keep that cool by water circulation. If this is done, commutators and all can be plunged bodily in. The moment cars are thrown off, the main shaft, lightened of its load, begins to speed up, and that moment the series dynamo builds up and puts load on until the total equals the former load, and the shafts keeps its speed. Throw load on the generators and the shaft slows a trifle, when the series dynamo dies out and no load is on the shaft but that of the generators. The output is always the same, but the amount of current from the main generators which passes to line, and the amount which passes to the regulator dynamos and used to heat water are constantly varying—that is all. The idea, of course, is only applicable where water-power is superabundant.

The New Westinghouse Glow Lamp.—The Westinghouse Company has issued the following circular to users of their incandescent lamps:—

In order that no one may be misled by the statements of the owners of the Edison patents with regard to the effect of the recent decision of the United States Circuit Court of Appeals for the Southern District of New York, sustaining the second claim of Mr. Edison's incandescent lamp patent (the other three claims having been held by the Court not to be infringed), we beg to announce to our customers, and to users of incandescent electric lamps generally, that we are prepared to receive orders for the delivery in quantities, after December 1st, of our new incandescent lamps, the manufacture of which has been established at our Pittsburgh factory. These lamps not only do not infringe the Edison patent above referred to, nor any of the patents of other companies, but they are fully covered by patents of our own. The new lamp differs radically from those now in use. It requires no platinum, and is made in separable parts, so that the incandescent burner can be renewed and the bulb and other parts of the lamp used over and over. Furthermore, by means of an important discovery, the burner is rendered stable, its efficiency increased, its life prolonged, and its normal candle power maintained. The manufacture of these lamps will be carried on almost entirely by machinery, and the first cost thereby considerably reduced, so that, with the advantages obtained from the re-use of the bulbs, a saving of from 30 to 50 per cent. to consumers in the cost of incandescent lamps for a given service will be effected. These lamps are in appearance a decided improvement over those now in use, and when used with a new socket designed for the purpose, a further reduction in the cost of lamp renewals will be effected, as no base attachment is required to make the connection with the socket. We are prepared to make advantageous time contracts with the users of incandescent lamps, with important allowances for the return of the bulbs to our factory.

The First Visible Colour of Incandescent Carbon.—Writing to *Nature* on a recent occasion on the subject of the first visible colour of incandescent iron, Mr. T. C. Porter describes how he tried a similar experiment with the carbon filament of an ordinary incandescent electric lamp. For this purpose he employed an 80-volt Edison-Swan 16-c.p. lamp; and the method of heating it gradually was to pass a current, supplied from a battery of accumulators, through the lamp and a water resistance, which latter was gradually reduced by the addition of sulphuric acid. The room in which the experiment was performed was very carefully darkened; and the observers were kept in darkness some minutes before the current was switched on. As the current was increased by regular stages, the observers (25 in number) carefully inspected the lamp in rotation, and every one of them wrote down his impressions of the colour of the filament in the dark, so that their eyes were not affected by extraneous light. Of the whole body of observers, all agreed that the colour of the filament was at first

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very pale. Thirteen called it a very pale yellow; three termed it white; seven a faint pink; two a bluish white. All agreed, also, that as the temperature rose, the colour grew deeper and redder, passing through orange *before* arriving at crimson. The words used to designate the final tint reached in the experiment varied from deep reddish orange to copper colour, dark red, blood red, crimson. In diffused daylight this would be called a dull red.

The Electric Cars in Boston.—The American electrical journals having done nothing but sing the praises of the electric cars at Boston, a correspondent of our semi-technical contemporary, the *Scientific American*, recently fulminated a vigorous counterblast, from which we take the following extracts: ". . . The facts are that electric cars have been the greatest nuisance that was ever put in the streets of Boston. . . Horses and men have been killed and injured by falling trolley wires, and one of the worst fires in Boston, where three or four million dollars' worth of property and several lives were lost, was set by an electric wire, which was supposed to have come in contact with the trolley system. The telephone system has been greatly impaired by the trolley wires, and accidents have been fearful. . . The capital stock, &c., of this Company has been increased from $6,400,000 to $16,400,000, with debts and liabilities amounting to $20,000,000, in four years. Although they have paid 8 and 10 per cent. dividends on their common and preferred stock, which, of course, has carried their stock somewhat above par, yet, when you consider that in Massachusetts dividends can be paid out of capital stock or borrowed money, it is easy to see how stocks can be sold above par. Outside of those who live a long distance from the centre of the city, and get cheap fares and extra speed in the suburbs, and those who have personal interest at stake, I think the electric road would be voted out of Boston."

The Electrolytic Preparation of Potassium and Ammonium Persulphate.—A memoir upon persulphuric acid and the persulphates is contributed by M. Berthelot to the last number of the *Annales de Chimie et de Physique*. To M. Berthelot is due the honour of the first preparation of persulphuric acid and its anhydride. The form of electrolytic apparatus which has been found by M. Berthelot to yield the best results consists of a double cell, the inner vessel of which is constructed of porous porcelain. The liquid contents of both the interior and exterior vessels are cooled by means of glass worms, through which a constant current of cold water is maintained. The inner cell of 150 c.c. capacity contains a concentrated solution of potassium or ammonium sulphate as required, in sulphuric acid diluted with six or seven times its volume of water. The nearer the composition of this liquid approaches to that of a solution of bisulphate of potassium or ammonium, the greater is the yield of persulphate. The exterior cell is filled with dilute sulphuric acid. The positive pole in the interior cell is best formed by a platinum wire, about one millimetre in diameter; persulphuric acid is found by M. Berthelot to be rapidly decomposed in contact with a large surface of platinum. Platinum sponge instantly decomposes the acid or solutions of its salts. The negative pole in the outer cell may conveniently take the form of a large plate of platinum. The current employed was three amperes. After about 15 to 20 hours the internal cell was found to contain large quantities of crystals of the persulphate. The usual yield of the potassium salt was 20·25 grammes, and of the more soluble ammonium salt as much as 40·45 grammes, in one operation. M Berthelot has also obtained potassium persulphate by the direct electrolysis of sulphuric acid and subsequent addition to the product of a concentrated solution of potassium bisulphate, crystals of potassium persulphate, KSO_4, being at once deposited. This mode of preparation is not so advantageous as the method o production by the electrolysis of potassium sulphate as above, but affords interesting proof of the formation of free persulphuric acid by the electrolysis of sulphuric acid.

The Dielectric Constants of Conducting Liquids.—In the *Journal de la Société Physico-Chimique Russe* (Vol. XXIII.) W. Stschegtiaff gives the results of some determinations by him of the dielectric constants of conducting liquids. To avoid the errors caused by absorption and the conductivity of the dielectric, it is necessary to use electrical oscillations of as short period as possible, or to arrange the experiment so that the errors mutually compensate each other. The author preferred the second method. The condenser was formed of three disks, two of which were fixed vertically at 5 millim. from each other, and the third could be displaced parallel to itself, this latter and one of the two fixed disks were connected with the electrodes of a Ruhmkorff, while the central disk was put to earth through a sort of Geissler tube formed of a small 5-volt incandescent lamp, the filament of which had been broken by too strong a current. This apparatus placed quite near the disk was extremely sensitive to electrical oscillations, the presence of which was shown by a light like that of Geissler tubes, while the static discharge of the condenser produced a spark. If the two extreme disks were not arranged so as to form two condensers of equal capacity with that of the middle, this latter was charged and the lamp was illuminated; by varying the distance of the movable disk this light could be annulled; it reappeared when the desired position had been passed. In order to diminish this error the mean a of the two distances was taken. If between the two stationary disks of the condensers a layer of a dielectric of thickness d is interposed, the constant of which is D, the movable disk must be displaced through a length x in order to make the light disappear. We have the equations

$$a - x = a - d + \frac{d}{D}; \quad D = \frac{d}{d - x}.$$

The liquids were placed in a glass trough with parallel sides. The results obtained are in agreement with Maxwell's law: $\sqrt{D} = n_\infty$.

	D.	$\sqrt{D}$.	n_∞.
Glass	2·263	1·503	1·538
Benzole	2·17	1·473	1·476
Water	1·75	1·323	1·323
Alcohol	1·62	1·273	1·353
Methylic alcohol	2·21	1·487	1·397

Fly-Wheels.—By an accident at the station of the Sioux City Electric Light Company, says the *Western Electrician*, all the lights in that city were instantly extinguished on the night of September 22nd. The accident occurred to the centre engine. The wheel, 11ft. in diameter and weighing 3 tons, was running at about 210 revolutions, when the belt leading from it came off. The wheel, relieved of its load, tore round at an alarming rate. The belt was thrown about, and, catching in the machinery of the engine, tore the governors off. The engine then went beyond control, and the wheel tore through the air at such a rate that it fairly churned the air in the room, tool-boxes, chairs, &c., whirling in every direction. Finally, the wheel burst with a loud report. Four pieces went up through the roof, 30 feet above. Two pieces, weighing upwards of 100lb. each, flew off to the north of the shafting. One struck the heavy brick wall about 5 feet above the floor and tore a hole completely through it. The other struck the wall nearer to its base, and its force was only sufficient to drive it about half through the wall. The force of the pieces flying off to the south of the wheel was broken by a large fender built around that side of the wheel to protect it. The fender was torn to pieces, and one of the pieces struck an iron steam pipe about a foot in diameter, and protected by heavy lagging. The piece tore a hole through the pipe. Another piece found its way up among the wires in the roof and short-circuited the dynamos supplying the arc circuits. This sent off the shaft wheels in another part of the station, and another huge belt slipped off, but fortunately did no damage. In the meantime the great belt on the shaft of the centre engine was being whizzed through the air. Every time it was carried down into and out of the wheel pit it struck the floor and dashed the boards nearest it to splinters. The flooring for a considerable distance from the wheel was torn up by the belting. Andrew Belt, one of the engineers, who was working near by when the belting came off, made a race through the shower of splinters for the cut off valve and succeeded in reaching it and cutting off steam. During all the time he was in the room the steam was escaping from the hole in the steam-pipe.

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SOME OF THE USES OF SEARCH LIGHTS.

BY R. H. BACON.

The various accounts of the several manœuvres of late years, when touching on the subject of search lights, have more or less left a general impression of their inutility. Correspondents on both sides of the opposed forces have freely criticised them, and most naturally so, since experienced torpedo boat officers do not consider them a formidable deterrent, and the authorities in the larger ships are sceptical as to their utility as a means of warding off a torpedo boat attack. Without in any way being dogmatic, it may be confidently asserted that considerable judgment is required before using a search light as a means of defence from a torpedo boat attack. It will be as well in explaining the peculiarities attending the practical use of the search light on board ship to consider the conditions by which a boat becomes visible by night.

Objects on the water or against the horizon are visible solely by the contrast of their colour or shade with that of their surroundings. Were the object exactly similar to its surroundings, naturally it would appear but as part of them, and be invisible. In bright sunshine it is impossible to imitate water so exactly in its varying colour and shades as to render a boat absolutely invisible upon it; so much light is always present ready to be reflected from all parts of an object that slight variations are easily detected, but at night this is different. Smooth water at night, when lit up by a search light, appears very dark indeed, and naturally so, since to an observer near a projector but few rays are reflected back from the small ripples; the water, therefore, appears almost black. Now place on this an object which also reflects but little light to the observer, such as a "dead" black boat (one painted with black lead), and the contrast between the two is almost *nil*; in fact, so nearly may the two sets of reflected rays match one another as to leave the boat, though in the centre of the beam, practically invisible from the ship. It is not sufficient to merely let the beam fall on the boat, but to see it it is necessary to produce a distinct difference between the light reflected by the boat and that reflected by the water. This at once explains a very common occurrence to all who have taken part in night attacks—that is, to find your boat brilliantly lighted by a search light beam, and yet for the beam to pass by harmlessly without the boat being observed by the ship. Nor is this all. Observers on board the ship are to a certain extent dazzled by the brilliancy of the beam even when at some considerable lateral distance, since the particles of moisture or dust in the air reflect and diffuse light to a considerable extent, and an effect is produced similar to, but, of course, to a less extent, of looking out of a light room into a dark night; the exact extent of the effect is determined by the angular position of the observer from the projector and object. There is yet another effect that limits the distinct vision of an observer near a projector, and that is the fact that when near a projector the rays reflected from an object have to travel back for some distance through the beam—that is, they suffer from considerable interference. The result is that the object appears indistinct. It will be easily seen that all these effects greatly reduce the efficient use of a search light when used to pick up an object if the observer is placed near the projector, as is usually the case on board ship, especially when the object is travelling towards the ship at a high speed. The practical proof of this is shown by the fact that a boat is rarely *itself* recognised in the first instance at any great distance, but originally attention is attracted to her by her bow wave—that is, the wave of foam, which reflects a comparatively large amount of light, and shows up distinctively against the surrounding dark-coloured water.

Were the above case, viz., that of detecting boats from a ship by means of a search light *in* the ship, the sole use of that weapon, it might, indeed, be an open question whether the electric beam is any material good in naval warfare, for there is one point which must never be forgotten, and that is, that the fact of burning such a light reveals the position of the ship to an attacking boat, when, by an absence of all lights, the darkness of the night might be a more efficient protection. It is this particular case which is the one that correspondents in manœuvres are most frequently brought into contact with, and on it opinion is so much divided that in open water it is probable that no captain would promiscuously use his search light as a method of defence. Happily, however, other occasions arise in war time when the search light is of great value. These may be divided roughly under two heads—(1) Defence of a fleet in close waters, where the position of the anchorage water of itself reveals the probable position of the fleet; and (2) Fleet action at night, or action between single ships.

Regarding (1) the case may be briefly stated as follows:—Ships are at anchor in a close anchorage for some particular reason, either for repairing or refitting purposes, or else the close presence of a superior force. For it is inconceivable, considering the deadly nature of a torpedo boat attack, that an officer would keep his fleet at anchor at night in a harbour that afforded by its position a possibility of an attack from torpedo boats if he could possibly avoid it. Supposing such the case, the search light may be a most efficient help against such an attack. Light may be burned at a distance from the ship on shore to light up the entrance or different sections of the passages through which the torpedo boats will have to pass, or the ships may illuminate the passages and use observers in their guard boats. In either case the effect is the same, for no longer has the light reflected from the attacking boats to be reflected at a small angle to the observer, but the observer is placed in a far better position as regards reflection, and far more minute differences in shade can be observed, since the reflected light is much greater. In other words, a greater contrast is produced between non-reflecting bodies and the water—gun fire can, therefore, be more effectively used, and greater havoc effected on the attacking force. In such a case, one thing is certain, for *detecting* boats all beams must be fixed so that observers may get their eyes accustomed to a constant intensity of light, and not a variable one, as produced by "sweeping" beams. This is the most effective use of an electric search light. A few beams may, of course, be kept in reserve for following up and illuminating boats after they have been detected, but these should be quite independent of the fixed beams. The guard boats, some two thousand yards away, can see the approach of others several hundred yards off, since the surrounding water is well illuminated by the beams of light playing on it. When the boats are discovered, it is necessary to light them up sufficiently for the guns' crews in the ships or boats to use their guns. This may be done by the ships' projectors with divergent lenses in conjunction with parallel beams, the divergent lenses being used to light the boats up, and from their large divergence prevent the chance of losing sight of them again, and the parallel beams to more brightly illuminate them and make them more clear to the guns' crews.

Again, in single ship or fleet action at night, search lights must be used to light up the enemy, and now the search light is no longer an objection, as showing the position of the ship, since its height prevents an accurate estimation of the position of the waterline (the most vulnerable position in the ship to fire at), but in reality it is absolutely safeguard, both since it is misleading as to the distance of the ship, and also is blinding to the opposing guns' crews. From the foregoing remarks it will be seen that the function of the search light may be either to *discover* or to *light up* an object for guns to fire at. These two different uses are important, since they lead to the height of the light being varied to some considerable extent. It has long been the opinion that for discovering boats the beam should be low, since its direction is parallel to the surface of the water, and, therefore, lights up a larger area than would be the case if thrown down on the water from a height, when the plane of the water would cut the beam in an ellipse whose area depends on the inclination of the beam. But a little thought will show that if the beam be parallel to the water the water is but feebly illuminated, whereas a body, vertical to the water, cuts the beam at right angles and receives a large amount of light. Were the body absolutely non-reflecting, it would be invisible; but if reflecting, a contrast will be obtained. Now that boats can be painted so as to be practically non-reflecting, the low beam is viewed with more disfavour, especially as *detection* is not the chief function of a light in a ship. The real function of the light *on board* is to light up an object

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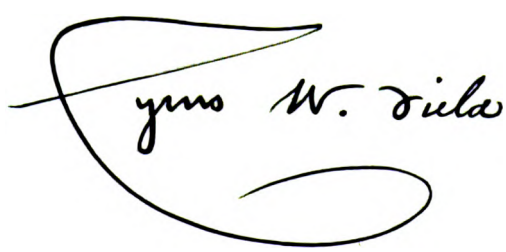

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whose approach has been detected, so that the guns' crews can accurately lay their guns. To do this it is necessary to keep the light as far from the guns as possible, and also to keep the beam off the water near the ship, so as to prevent the men being dazzled. The best position in the case would appear to be to have the light above the guns, so that the crews practically do not see the beam, except where it strikes the object, and also should the opposing ship use the light to aim at the shot will be more likely to pass over the ship. Another great point is to have the projectors so placed as not to illuminate any portion of the side or superstructure of the ship; this, again, is best obtained by a fairly high position of the light.

For attacking forts or in action in moderately smooth water a light in the military tops would seem to answer these requirements; but, of course, with even a moderate motion of the ship a beam from a projector so placed would sweep through a far larger arc than one in a lower position, and would, therefore, be far harder to keep steadily illuminating an object. For navigating purposes, where the water close to and for some distance ahead of the ship has to be illuminated, a low position of the light is best.

For signalling purposes, at night a beam may be thrown on a cloud, and its reflected light will be seen at considerable distances; the distance, however, depends on the height and position of the cloud, and a general rule as to visibility cannot, therefore, be even approximately laid down.

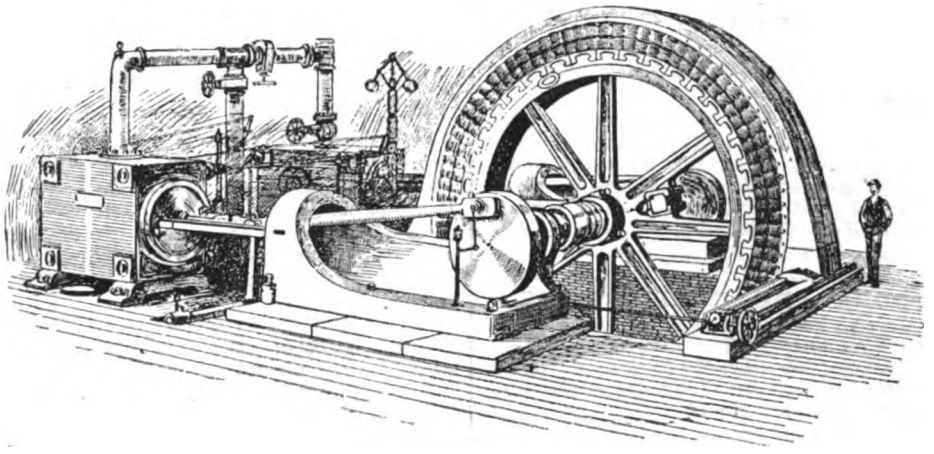
In this short article many points have been intentionally omitted. The position of observers has no interest except to those technically connected with the service. Automatic lamps and projectors, though of great importance, are beyond the scope of the present outline, which is only intended to point out a few of the many difficulties and problems that arise in the practical use of the search light. So much criticism on the lights has been passed in late manœvures, that it is only fair to point out that isolated uses of the light in manœuvres (and those generally in one particular and that the most inefficient occasion, viz., the detection of boats) are not the sole uses, and that, therefore, it is unfair to judge of the importance of the light to the navy by them. Our material is excellent, thanks to the makers; we cannot say the best, since the best is never arrived at, and all things improve day by day, but the failure of the light to do all that we wish is rather our own faults for expecting it to fulfil the condition of daylight, when after all our 5,000 watts can but give us a definite amount of light which in its turn has to obey the inexorable laws of optics.

A LARGE WESTINGHOUSE ALTERNATOR.

In the station of the Narragansett Electric Lighting Company, of Providence, R.I., two large dynamos are in the process of erection. One is being constructed by the General Electric Company, and the other by the Westinghouse Electric and Manufacturing Company. These generators have each a capacity of 500 H.P., and are direct driven at 90 revolutions per minute by a cross-compound automatic cut-off steam engine of special design, built by the E. P. Allis Company, of Milwaukee, Wis. These engines are alike in size; the high-pressure cylinders are 19in. in diameter, and the low-pressure cylinders 36in., with a stroke of 48in. The cylinders are steam jacketed. The two engines are set in the western portion of the engine house, and rest on a foundation about 50ft. square. Large granite stones were bedded into the brickwork foundation where required, the top stones being faced off to receive the engines.

The Westinghouse generator, an alternator, is nearly completed, and it will soon be in operation. A good idea of its construction may be obtained from the accompanying illustration, which we take from the *Electrical World*. In this case the armature is actually built upon the original flywheel of the engine. The 80 coils are wound on lathes and slipped into place. The cores are made up of thin plates of special iron, some 60,000 of these plates being used in the construction of the armature and field. A device is provided for moving the field to one side away from the armature, so as to give free access to all parts of both.

The current is taken off by large brushes from ring collectors upon the shaft. The field is excited partly by a separate machine, and partly by a current from the dynamo itself. The number of alternations is 120 per second. This machine is guaranteed to deliver 373,000 watts, with a maximum rise in temperature not exceeding 54° F. above the surrounding air. An efficiency of 92 per cent. is guaranteed, but it is expected that the actual commercial efficiency will be about 94 per cent. The following dimensions give some idea of the size of this machine:—The foundation space occupied is 42ft. by 21ft. 6in. The outside diameter of the field is 19ft. 7¾in., while the diameter of the flywheel is 16ft. The weight of the armature and of the field complete will be about 90,000lbs.



New 500 H.P. Westinghouse Alternator.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, October 28th.

PHYSICAL SOCIETY.

5 p.m. Paper to be read: "The Determination of Critical Density, Critical Volume, and Boiling Points," by Dr. Young and Mr. Thomas, to be discussed together with the Paper on "The Laws of Molecular Force," by Mr. Sutherland, and "The Dimensions of Physical Quantities," by Mr. Williams.

OLD STUDENTS' ASSOCIATION.

7.30 p.m. Annual Dinner at the Holborn Restaurant.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at St. James' Hall Restaurant.

FRIDAY, November 4th.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Presidential Address by Dr. John Hopkinson, F.R.S.

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The Electrician.

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COMMERCE AND COERCION.

At the thinly-attended meeting at Botolph House on Friday last, the subjects discussed afforded some interesting examples of coercion. In the first of these it is true, coercion was abortive, but if a fair number of members had thought it worth while to exhibit at Chicago, many others would have been forced to do the same. The only symptom of coercion in this instance was the record of the withdrawal of the rule which forbade the display of duty-free prices. This subject having been dismissed, the old question of overhead wire regulations came up again. This has been discussed so fully in our columns that it is quite unnecessary to go into details, but attention may be drawn to the fact that more than three years have now elapsed since these rules were issued. It is said, but not officially we believe, that these rules were provisional, and we are glad to learn that a committee of the Institution of Electrical Engineers has been appointed to consider the matter. It would be a great pity if the Institution were to take up an anti-commercial attitude when questions of this kind are laid before it. When the London Chamber of Commerce invited this body to take joint action in connection with Electrical Standards, and the establishment of a Board of Trade Laboratory, scientific niceties

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seemed at one time to be opposed to commercial considerations; but as soon as the intentions of the Government Department were understood, the professors were left to deal with their definitions. Scientific refinements in connection with overhead wires have led to ridiculous results, and the whole question of sparking distances which then determined the thickness of the insulation, has been thoroughly investigated since the promulgation of the rule of thumb standard of a twentieth of an inch for every thousand volts. Regulations of this kind made, perhaps, in haste or with too much caution, can be modified after three years' trial, but to complain that there are signs of over-regulation and interference in the future is another matter. Hitherto the Board of Trade have sought the advice of the Institution of Electrical Engineers on technical details, and if, as it happens, the active members of the Council consist of professors and consulting engineers, with only a small minority of men engaged in trade, say half-a-dozen out of thirty-three, it would be only fair that when a trade matter arises, the Electrical Trades Section of the London Chamber of Commerce should have, not an exclusive, but an equal hearing with the strictly scientific body. But when it is said that there was never any intention on the part of Parliament that the Board of Trade should have power to regulate operations of electrical contractors in detail, it must be remembered that we have entered upon an age of regulations; some petty, some preposterous; and if the electrical trade is to be subject to any authority, it can be in no better hands than those of the Board of Trade. On a former occasion we expressed a wish to see an electrical department fully equipped and comparable with the other practical branches of this office. In whatever direction the Board of Trade may stay its hand, there assuredly will the County Council step in; at all events where London is concerned. And if such withdrawal from responsibility is encouraged by an outcry about over-regulation, an excellent example of King Log and King Stork will be afforded; with this difference, that the modern meddler is impelled by zeal of reform and thirst for economies, while his prototype frankly confessed that he eat the frogs because he liked them.

Having settled this bit of coercion for the present, by the appointment of a committee, from whose exertions emancipation or relaxation of the obnoxious rules is hoped for, the meeting went on to listen to three propositions for the self-imposition of restrictions and prohibitions, which if suggested by any outside body would be received with a storm of denunciation. Students of human nature will note that when it comes from within, the more proscriptive the ordinance, the less indignation it arouses; and when matters reach a climax of coercion, the question simply ceases to arouse discussion. The first of these proposals was one which claimed the attention of the Electrical Trades' Section at its first meetings, and a committee, consisting if we remember aright of the whole of the manufacturing members, was appointed to consider it. The standardising of machinery sounds well, and we may point with pride to our $\frac{7}{8}$in. lamp caps, which fit all B.C. sockets to a nicety, compared with the clumsy taper-thread expedient of the common gas burner. The B.A. screw-thread has been successfully introduced, and at one time it was hoped that the frequencies of alternators might be systematised. But the present proposition seems to be concerned chiefly with speeds, voltages, sizes of machinery, and insulation of cables. Of these, the question of voltage is comparatively simple, and Major Flood-Page so far forgot his habitual caution in questions of lamp making as to confide to the meeting his anticipation that lamps will be divided into two classes, lamps for supply systems, and others. This may be taken to mean, we suppose, that 100-volt and 50-volt lamps will be cheaper than lamps of fancy voltages. The only excuse for using other lamps is the custom of running arc lamps in parallel at 60 or 70 volts, though the best lamps are now made to run on 50 volts; and the standard of the Navy where 80 volts have been adopted. This proposed difference in price is very natural, but it will tell hard on the unfortunate townsfolk of Brighton and Bradford for whom meters have to be specially rewound, since their supply is fixed at 115 volts. The Board of Trade, before sanctioning such fancy standards of pressure, might suggest to the local authorities that such a departure from the established practice is likely to be troublesome if not unnecessarily expensive.

The uniformity of speeds and sizes of dynamos is but a single question, and appears not only hopeless to attempt, but ill-calculated to produce "much larger margins of profit, which, after all, was the point they were all aiming at." The speaker suggested that if an account of the distinct types of machines of the several manufactures in England were drawn up, that members would be surprised to find the enormous number of varieties therein contained. Such a list is readily found in "*The Electrician* Electrical Trades' Directory," and the result is simply expressed by the statement that last year there were 4 firms who offered more than 20 sizes of machines, 8 who offered more than 15, and 11 with more than 10, making 249 sizes in all of continuous current dynamos only. By sizes we mean separately marked types in the catalogue. Some of these are almost identical but for an alteration of speed. But one aspect of this splendid choice is that the purchaser has a magnificent assortment to choose from, while one manufacturer at least will be able to "fill the bill" from stock. Purchasers, however, were scarcely mentioned at Botolph House, and it was the consulting engineer who was blamed for specifying one particular speed when some unhappy maker could have supplied a dynamo to do the work, if allowed to run a little faster. A specification rarely defines a speed, but sets a limit beyond which the dynamo-maker must not pass. Nothing is said about slower speeds, unless the engine-maker is concerned. In Admiralty work, where weight is of importance, and where the engine-maker sometimes claims greater consideration, it is he who sets the lower limit, below which he cannot supply the power, while the obvious conditions of the work define the maximum speed. The narrow range thus allowed has called forth the greatest skill in dynamo design, and has put the whole art on a far higher level than where a dozen standard sizes alone are made. We grant that a scheme of standard sizes looks at first glance attractive, but if adopted by the leading manufacturers —a manifestly absurd idea—what coercion is to prevent a new maker from proposing to build a machine to suit any specification; and, after all, was not this the origin of a large majority of these various types? We cannot go into the question of cables. Let the cable-makers first prepare a standard list in which a 300 megohm insulation shall, for want of a better designation, denote a particular quality; we may then judge whether this is good enough for any particular purpose; but at present the 2,000 megohm quality of one firm is little, if any, better than the 600 or even the 300 megohm class of another.

On the diversity of prices in tendering for the same work we have often commented; the best cure is the very bit of coercion about which complaints have just been made, viz., a strict specification. The sixpenny telegram and the other examples of uniform prices given to the meeting were no examples at all, and "to bring a certain standard of work into practice, and to get nearer to a uniformity of price for that standard," belongs to

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the visionary Utopias of speculative socialism. The question of tenders in connection with specified speed has a bearing on the important question of the rights of the lowest bidder, and on one branch of this subject an interesting article, reproduced from a contemporary, will be found in another column. If a maximum of 500 revolutions per minute be specified, and a first-rate dynamo maker offers to supply a machine, perhaps at a reasonable price, but at 510 revolutions, according to one notion, the fad of the consulting engineer ought to give way; but is this just to all the other contractors who are prepared to do that which has been asked? A Paper might with great advantage be read by some experienced contractor before a meeting of the Electrical Trades Section and perhaps other sections of the London Chamber of Commerce, and followed by a discussion. Such a Paper, which would be altogether out of place at the Institution of Electrical Engineers, would probably draw a good audience; it being understood that any member using the word hysteresis or lapsing into mathematics would be at once ejected.

The last proposition submitted to the Section at Friday's meeting was, perhaps, more suited, in the present state of the question, for rhetorical sparring at a debating society than for a meeting of business men. For many years no politician has wasted words about Protection; for one party this would have been but to flog a dead horse, the other party dared not mention it, and rash outsiders who disparaged free trade were told that "that cannot come up at this election." Tariffs are, however, a common topic to-day, but as politics must be excluded from these columns, we would merely ask by what process of coercion is a gallon of lubricating oil (not the containing vessel) to be stamped or branded with the proposed British trade mark.

CYRUS W. FIELD.

We issue with the present number a steel portrait of the late Mr. Cyrus W. Field, who may justly be described as the Pioneer of Ocean Telegraphy.

Having shortly after his death given a notice of the principal events of his life (vide *The Electrician* of July 15, 1892), it is not necessary here to go over the same ground, but we find that, in the opinion of those who knew the late Mr. Field best, adequate justice has not yet been done to the magnificent energy and irrepressible perseverance with which he toiled almost day and night for many years until, after frequent failures and crushing disappointments, which would have shaken the courage and endurance of almost anyone but himself, the object of his life was accomplished, and electrical communication between the Old and New Worlds was established, which, with ten cables existing in the North Atlantic alone, is not likely ever to be severed, even temporarily. A characteristic instance of his undaunted attitude, in face of misfortunes which seemed to augur the final failure of the enterprise, was afforded in the case of the second expedition. When the cable parted and his colleagues in the great work were considering whether it were possible to recover the cable, Mr. Field, after retiring to his cabin for a time, reappeared with a draft prospectus in his hand, designed to secure the capital necessary for the laying of a new and improved cable!

As showing the extent to which the enterprise dominated his mind, it may be mentioned that in one of his speeches the late Mr. Field said he had frequently prayed that he might be spared until sub-Atlantic telegraphy had been accomplished, and there is no doubt that, having once entered on the undertaking, he devoted himself and all his inexhaustible energy to the carrying out of the task, neglecting his private affairs, and giving neither himself nor anyone else who might help in the work any rest until success was attained. It is not too much to say that but for his unwearied persistence Atlantic telegraphy would have been postponed for several years at least, and that the world-wide system of submarine cables would not be so extensive and complete as it now is.

The steel plate portrait which accompanies the present number was engraved from a photograph of the painting of himself presented to the late Mr. Field in public acknowledgment of his services to the world in the cause of ocean telegraphy, and is a very faithful reproduction. Mr. Field was born at Stockbridge, Massachusetts, U.S.A., in 1819, and died at New York on July 12th last.

GEARING.

BY E. TREMLETT CARTER.

(*Concluded from page 668.*)

Helical Gear.

We have seen that one of the most serious objections to the ordinary form of spur gear is the irregular running caused by the drop of the teeth on to one another as they come into gear. The greater the pitch of the teeth the more drop will occur, and even with the best form of teeth it is impossible to altogether eliminate the vibration which ensues. In certain classes of electrical work it is impracticable to permit these vibrations, while at the same time it is desirable to have a more positive form of gear than is found in those kinds which depend only on a frictional grip. Such a form is found in helical

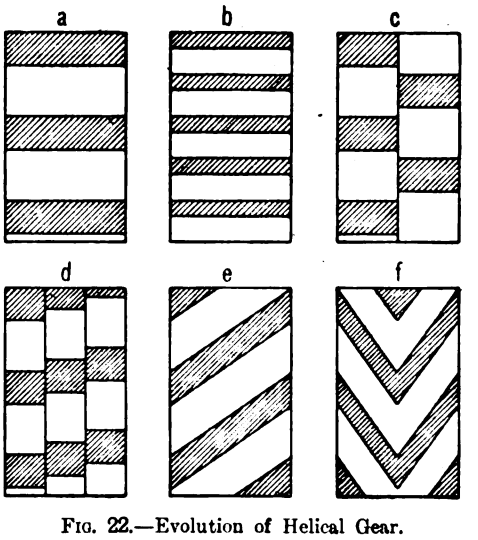

FIG. 22.—Evolution of Helical Gear.

or screw gear. The action and evolution of this gear is explained by the series of diagrams in Fig. 22. At *a* there is an ordinary spur gear; the teeth, having long pitch, being shown by the shaded portion. The drop in these teeth would be very large, but it might be reduced by having a gear shown at *b*. In this the pitch is reduced, and the number of teeth increased in proportion; the frequency of the teeth coming into gear being doubled, there would be only half the drop with each tooth. But, the thickness of each tooth being reduced to one-half, the strength will be reduced to one-quarter of the former value, a contingency which would probably render *b* useless. It is possible, however, to increase the frequency of the teeth without reducing their thickness; and a form of gear which will do this is shown in *c*. Here one-half of each tooth is displaced forward by an amount equal to half the pitch, the effect of which is to cause the right and left halves to come into gear alternately, and to double the frequency and halve the amount of drop. By having three sections to each tooth, and displacing each section forward by one-third of the pitch, as shown at *d*, the frequency may be trebled, with the result that still less vibration will occur. Now, it occurred to Dr. Hooke, the inventor of helical gear, that by having an infinite number of sections, and displacing each section an infinitesimal amount forward, the drop should be entirely eliminated, for there would be always some portion of some tooth in gear. Such an arrangement would form a slant tooth as

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shown at *e*, and since such a tooth would really be a part of a screw wrapped round the wheel, the name helical or screw gear has been given to it. The slanting surface of the thread or tooth at *e* would set up a reaction in the direction at right angles to the motion of the wheel, causing an injurious side thrust on the wheel and an end thrust at the bearings. To obviate this, one-half of the thread is slanted in an opposite direction to the other half, the threads being right and left-handed. The thrust due to each half of the gear will balance that due to the other half, and thus, though there will be a bursting stress on the material of the wheel,

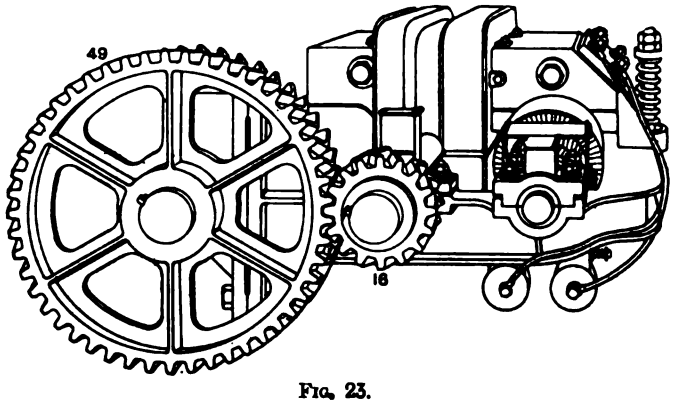

FIG. 23.

there will be no end thrust at the bearings. Owing to the advantageous position of the material as it takes the pressure of the thread in which it is in gear, the strength of helical gear is 20 per cent. stronger than spur gear of the same pitch and material. In regard to its regularity in running, it is said to be smoother than morticed gear and to be as silent as belts or ropes. It is doubtful whether this gear can be adapted to traction work, owing to the necessity for strict parallelism and relative position of the wheels; but it has been successfully applied to motors for pumping, haulage, and mining work. The manner of fitting helical gear to an electromotor is shown in Fig. 23, in which a pinion of 16 threads on the countershaft is geared into a wheel having 49 threads on the machine shaft. The first motion gear on the opposite side of the motor, is not shown.

Chain Gearing.

The well-known bicycle chain gear has been several times tried in connection with electric traction work, but has not

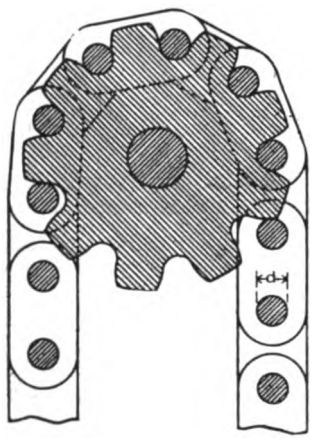

FIG. 24.

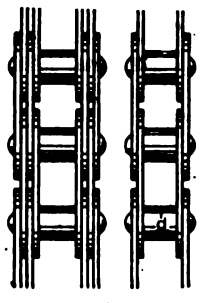

FIG. 25.

proved successful where much power is to be transmitted by it. Difficult to design and construct so as to be efficient and durable, and troublesome in working, this form of gear has only its positive grip, and the flexibility which permits of considerable relative movement in the shafts to recommend it The construction of the most common chain is shown in Figs. 24 and 25, the former showing the side view of the chain and chain wheel, and the latter showing how the chain is built up. The links are formed of a number of flat strips of steel plate, composing two sets of alternate links by being riveted on to a number of steel spindles. The spindles are turned to a shoulder at the links, being 20 per cent. thicker in the middle portions, and the heads fit sufficiently loosely for the links to have free motion in the plane of the chain. In many cases the middle part of each spindle is loosely covered with a steel thimble, which provides a rolling instead of a sliding motion as the chain gears with the teeth of the wheel. Each link is usually composed of two or more strips in parallel; but the strength of the chain cannot be indefinitely increased by adding strips, for when the thickness of the compound chain has reached a certain value the flexure of the spindle end will set up a compressive stress on the outside strips, rendering the chain actually weaker than a narrower one would be. Nor can the strength of the gear be very much increased by increasing the depth of the chain, for this would necessitate long and fragile teeth; it would also produce inefficient running, on account of the increased friction between the chain and the wheel. For these reasons the material of the links must be worked with a small factor of safety, and the result is that the links rapidly stretch, and the chain no longer gears well with the wheel. To partially prevent this, the links are sometimes made numerous and very short; but even here there is a limit in the reduced thickness of the teeth. Owing to the flexure of the spindles the inner strips are subjected to more stress than the outer, and are sometimes made thicker; with two strips, for example, the stress on the inner one is 90 per cent. of the total pull on the chain. Prof. K. Keller, who has investigated the best conditions for this gear, recommends the following proportions:—Taking d as the diameter of the spindle inside the strips, the diameter of the mid portion of the spindle should be $1{\cdot}2d$, and the width of this thickened portion should be $(1{\cdot}7d + 0{\cdot}2)$. The outside measurement of the link should be $2{\cdot}5d$ wide, and the pitch (from centre to centre of spindles) should be $2{\cdot}9d$. In order to prevent variation in the stress on the chain the number of teeth on the wheel should never be less than five, and is preferably eight or more. Wheels with four teeth have been tried, but the variation in load on the chain was found to lead to rapid deterioration.

This form of gear has been tried on the Berlin-Lichterfeld electric tramcars, and on some cars designed by Mr. Reckenzaun in London; it is also in use in America on cars designed by Van Depoele. At Berlin it was found that the gear, which replaced the steel spiral cord gear described in a former section, resulted in considerably reduced speed in the cars, but that it was able to take the cars up a steeper gradient, and to start them more quickly. The gear, however, ran very noisily, and with great vibration, as was also found to be the case in the London cars.

ELECTRIC LIGHTING AT HAVRE AND BOULOGNE-SUR-MER.

The Central Station of the Société l'Energie Electrique at Havre is a substantial brick building containing the usual offices, workshops, and stores, and is situated close to the railway station, lying between it and the coal dock, where all the coal ships are discharged. The power for driving the dynamos is supplied by two large single-cylinder Corliss engines, constructed by MM. Farcot, each capable of developing 450 I.H.P. The number of revolutions per minute is, under the ordinary working conditions, about 55. The fly-wheel weighs about 15 tons, and is 21·7ft. in diameter, with 10 grooves in the circumference, in which run the cotton ropes driving the dynamo. Each engine has an independent air pump and condenser, but if necessary the steam can be exhausted direct into the atmosphere, and the boilers fed with fresh water from a tank supplied by the water mains of the town. The water for condensing purposes is drawn from the dock. The boilers are five in number, and of the Berendorff type, with 1,750 square feet of heating surface each. There are two 244-kilowatt Ferranti dynamos, but under ordinary working circumstances they only give out 100 amperes at 2,400 volts. The collectors, method of oil circulation, and other details are all of the usual Ferranti type and do not call for any special remark. The current, on arriving at the

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switchboard, passes a large Ferranti fuse, voltmeters, and small double-pole switches of the same type that are used with the small transformers employed in the houses of the consumers. The board is also fitted with a Thomson electrostatic voltmeter, a Carpentier voltmeter, a Thomson ammeter, and three large commutators, which enable the various circuits to be switched on to either machine. A Richard registering ammeter shows that the maximum output is registered between 5 and 7 p.m. There are also two Cardew voltmeters, and the necessary resistances for the exciters.

The cables have sections varying according to their position in the circuit and are of 0·0108, 0·02015, 0·0434, 0·0868, and 0·1736 square inches section. The main circuits are two in number and are each capable of carrying 100 amperes, *i.e.*, 240,000 watts, which is equivalent to 6,500 lamps of 10 c.p. each. The mains are composed in the centre of tinned copper wires, surrounded with a layer of pure india-rubber, then two layers of vulcanised india-rubber bound round with two layers of india-rubber strip, then a layer of jute, the whole being sheathed with iron wires, No. 9 B.W.G., and covered with a final covering of jute soaked in bitumen. The cables are simply buried, no conduits being used, on account of the low-lying level of the ground and its extreme humidity. After a year's running an insulation test was made which gave very satisfactory results. The transformers are usually placed as near as possible the entrance of the primary leads into the houses so as to minimise the risk consequent on having any long lengths of wire under high pressure in the houses. One large transformer is sometimes used for several consumers when they are situated near together. The size of the transformer is so chosen that the number of lamps for which it is designed corresponds to the normal number of lights usually alight, and not the maximum number of lamps fitted. Before passing into the transformer the current passes through a two-pole switch and a

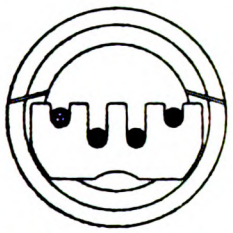

Fig. 1.—Boulogne Central Station. Stoneware Conduit.

fuse, and the secondary current on leaving the transformer passes through a cut-out, especially designed by the Company. The current finally traverses the meter, which is always situated in as dry a place as possible. The cost of the supply is about the lowest on the Continent, being 7·7d. per kilowatt hour.

At Boulogne-sur-Mer, on the other hand, the system adopted is very different. When the Société pour la Transmission de la Force undertook the electric lighting of the town, another large scheme was afloat, namely, the electric lighting of the railway station. The site selected for the railway station plant was naturally close by, and when it was subsequently decided to merge the two schemes into one, the railway station site was retained, although it involved the disadvantage of having the generating depôt on the wrong side of the river and a long way away from the part of the town where customers were to be anticipated. Hence the necessity for the adoption, if the three-wire method of distribution was to be adhered to, of the somewhat cumbersome system to be described.

The generating plant is on the left bank of the Lianne, three-quarters of a mile from the distributing centre on the Place Frédéric-Sauvage. Two horizontal condensing Weyher-Richemond engines of 125 H.P. each drive through belting two 350-volt, 250-ampere Desroziers dynamos employed to charge a battery of 138 storage cells placed at the distributing centre; a smaller machine supplying current to a battery feeding the lamps at the Gare du Nord. The line is overhead for the most part. The distributing net work consists partly of bare copper conductors in trenches, and partly of *insulated* cables laid in stoneware pipes and supported on glass saddle pieces (*see* Fig. 1). It is probably owing to these precautions that the use of these stoneware pipes has not in Boulogne given rise to the mishaps which have occurred in Paris. The central station has been at work for about a year with satisfactory results. Some 5,000 lamps are at present connected to the mains. The price of the hectowatt hour is 12 centimes, which is practically equivalent to the Board of Trade unit at a shilling. The price of Boulogne gas is about 7s. a thousand. Brillié meters are almost exclusively employed.

The switchboard at the distributing centre contains, besides the usual hand devices for switching cells in and out of circuit as circumstances may require, an arrangement shown in Fig. 2 for interchanging the position of the two halves of the battery, with regard to the neutral wire. This interchange is carried out every day at noon, with a view to preventing unequal charge and discharge of the two sets of cells. On the board are arranged four series of jaws, the two on the right belonging to one half of the battery, and the other two to the other half. Two sets of contact pieces revolve on two spindles situated between the rows of clips. By means of a worm and two

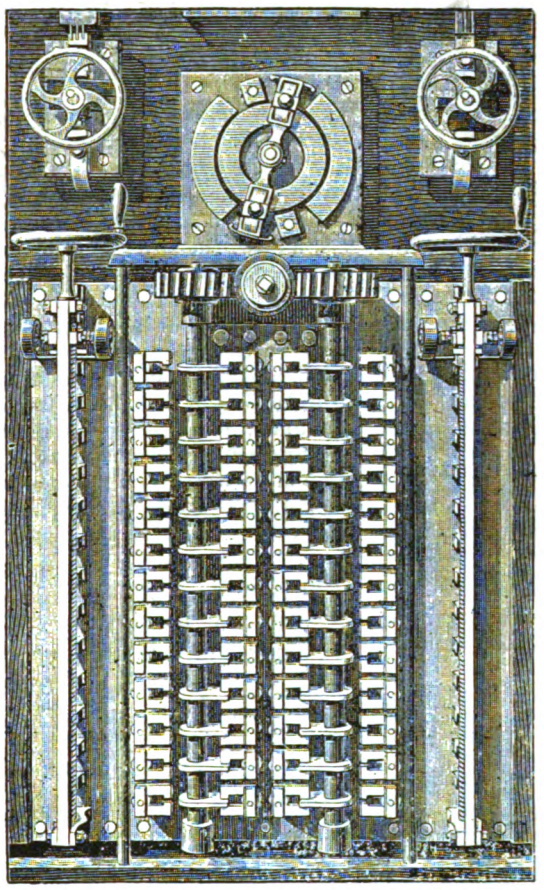

Fig. 2.—Boulogne Central Station. Switchboard for Transposing the Two Halves of a Storage Battery connected to a Three-wire Circuit.

toothed wheels, as shown, both the spindles are rotated at the same time, and the two halves of the battery interchanged. The whole operation is stated by *La Lumière Electrique*, to whom we are indebted for some of these particulars and for the illustrations, to take "hardly two or three minutes, and to cause no trouble to the supply."

Kensington Vestry.—At a recent meeting of this Vestry Mr. F. L. Chandler moved, "That inasmuch as complaints are being made by residents in the district of North Kensington, included in the area allotted to the House-to-House Electric Lighting Company of their failure in not supplying electricity, it be referred to the Works and Sanitary Committee to consider the best steps to be taken to compel the Company to carry out the provisions of their Order in regard to the laying of distributing mains in the district referred to." This was agreed to.

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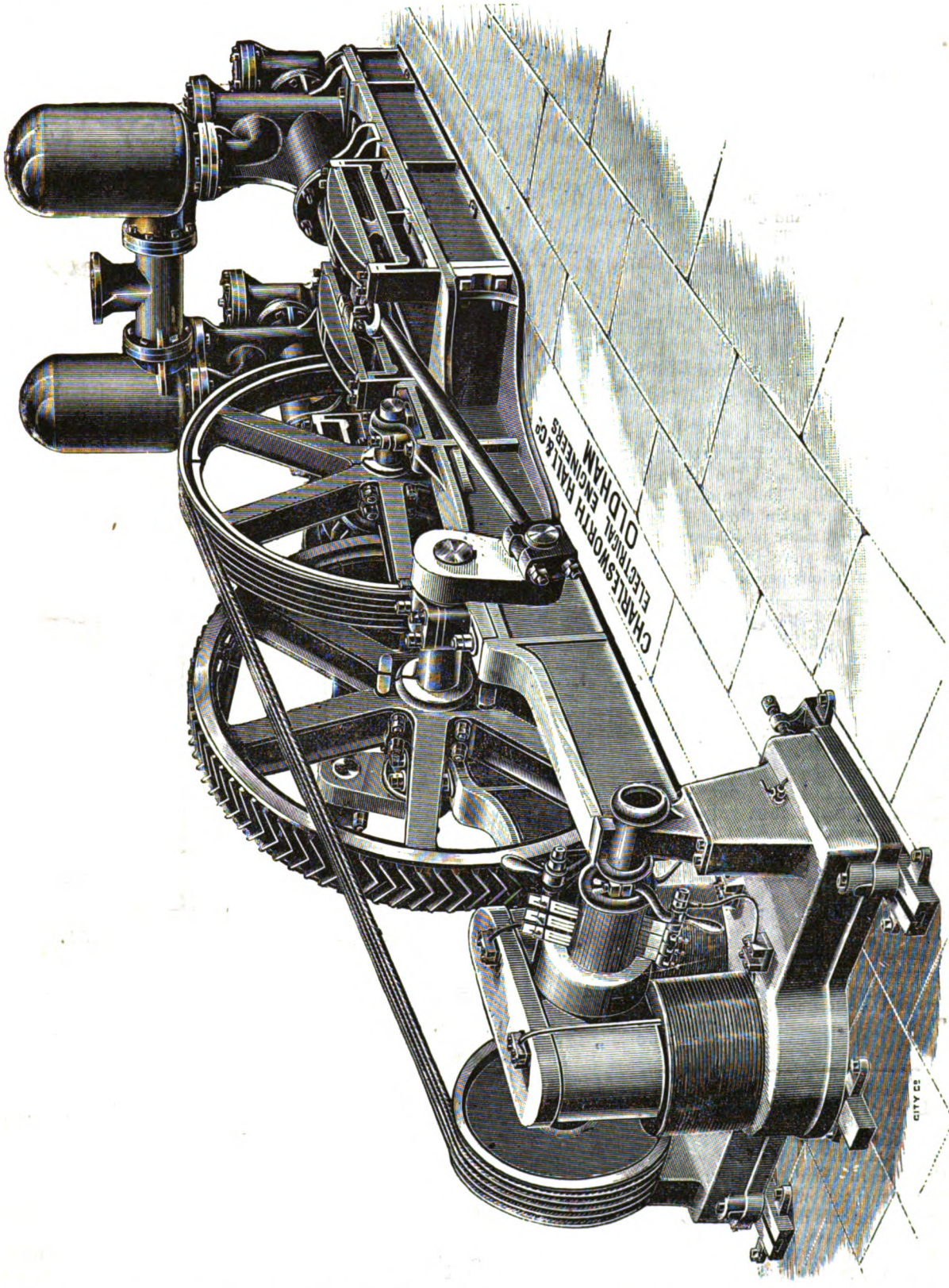
ELECTRIC PUMPING PLANT.

This plant, constructed by Messrs. Charlesworth, Hall and Co., for Messrs. Platt Brothers and Co. (Limited), for Jubilee Colliery, Shaw, was installed in November, 1890, and has since then been running continuously from 100 to 150 hours per week, except for four or five hours on a few occasions through the fuses, &c., burning out through various causes. It consists of a steam engine on the surface, working a dynamo which supplies current to a motor below fixed in one of the roads about 750 yards from the bottom of the shaft, at a depth of 120 yds. This drives a pump delivering its water into the sump, and from thence is raised to the surface by the main steam pumps placed at the bottom of the shaft.

The steam engine is an old single cylinder condensing, much too large to work economically with the dynamo only. The following are the particulars as taken during a test on 23rd January, 1891 :—



Electric Pump by Charlesworth, Hall and Co. Capacity, 577 gallons per hour, raised 142 feet.

The cylinder is 28in. in diameter, and has a 42in. stroke running at 54 revolutions per minute, and driving from a 15ft. flywheel rope pulley on to a 4ft. pulley on a countershaft with six 1½in. ropes, and a 6ft. pulley on the countershaft drives a

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2ft. 6in. on the dynamo by six 1¼in. ropes. The engine indicates 21·58 with the brushes off the dynamo, and 62 H.P. with ordinary load, which is equal to about 36 per cent. of the full load power given out by the engine.

The dynamo is an "Oldham" series-wound machine, giving a current of 48·5 amperes at 580 volts = 28,230 watts, or 37·7 E.H.P. at 490 revolutions per minute when absorbing 40·1 I.H.P.

The cables are 37/17s lead covered, and are carried down the shaft and at the bottom in strong wood casing to protect them from mechanical injury, and are laid in a trench along the road below the surface, and at the side of the rails. Their resistance is 0·334 ohm, which at ordinary load as above = 1·05 H.P. loss.

The motor is in all respects similar to the dynamo, and, when taking 48·5 amperes at 567 volts, runs at 406 revolutions per minute, and gives out 35·53 H.P. It drives the pump with six 1¼in. ropes from a 36in. pulley on to one 7ft. diameter on pump. On this shaft is a double-shrouded helical steel pinion, with 18 teeth, gearing into a wheel having 90 teeth on the crank-shaft, which has two cranks of 15in. throw; the rams of the pump are 9in. diameter, and ran during the test at 35 revolutions per minute, indicating 24·3 H.P. on the water cylinders, and delivered 577 gallons per minute, against 142ft. vertical head. The engine-room is provided with both volt and ammeter in a convenient position in view of the engineer when starting, the pump-house also is provided with an ammeter, so that the man in charge of the pump can see that all is working easily.

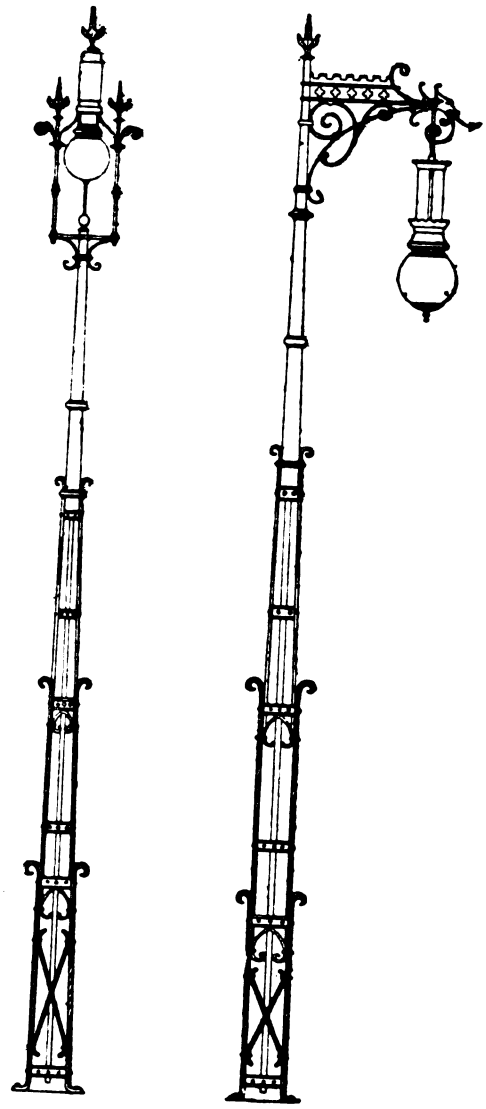
Main high-tension water-break fuses are fitted on both mains in the engine-room in close proximity to the dynamo. The engine-house on the surface, and the pump-house below, are connected with a signal-bell. The pump-house is lighted with incandescent lights off the main circuit. The following table gives the results of a test made in January, 1891, in which all the various sources of loss were tested separately, and are as accurate as colliery conditions permit:—

Power given in.	Engine gives 62 I.H.P., which is accounted for as below. I.H.P.	I.H.P. of engine, accounted for as below. Per cent.	Actual H.P. received by dynamo, accounted for as below. Per cent.
Power lost between engine and dynamo with full load	21·90	35·31	—
Power lost in dynamo	2·26	3·65	5·67
Power lost in cables	1·05	1·69	2·62
Power lost in motor	2·26	3·65	5·64
Power lost in pumps and gearing when working at full speed..	10·23	16·51	25·50
Power lost by friction of water in pumps and pipes.....	4·58	7·39	11·40
Calculated power represented from the *actual water raised* by the pumps allowing nothing for friction or losses.	19·72	31·80	49·20
	62·00	100·00	100·00

Power used by dynamo available at motor = 86·1 per cent.
Losses in dynamo, cables, and motor = 13·9 "
100·0 "

LAMP POSTS FOR OXFORD.

The arc-light posts which now adorn all the main thoroughfares of the City are in their way an interesting instance of progressive development from the distinctly ugly to the passably ornamental. The first half-dozen eyesores, with their peg-like excrescences, were heavy to an extreme; then followed a lighter type of post with some pretensions to the artistic, and within the last week or so a still more ornamental type has appeared upon the scene. "Made in Germany" is generally a synonym for "mediocrity," and often for "cheap and nasty," but this applies more to small and sundry goods than to important engineering construction. "Designed in Germany," on the other hand, conveys a very different idea, though why this should be the case, when Art Schools are scattered up and down the country, it is difficult to see. The Oxford Electric Light Company have had to go all the way to Munich in order to obtain patterns for lamp posts in keeping with Oxford architecture. In good time, no doubt, an entirely new species of post will be evolved, having a less pronounced likeness to a magnified gas lamp than is the case with the arc-light supports which at present form a marked addition to the numerous obstructions that impede pedestrian traffic along the narrow pavements of



Lamp Posts for Oxford, Designed at Munich.

Fleet-street and Cheapside. These Oxford lamp posts seem to be a great advance on anything that has yet been erected in this country. The extreme height of each pattern is 25 feet.

THE NEW SHORT GEARLESS MOTOR.

One of the most interesting exhibits at the National Street Railway Convention at Cleveland, O., will, says the *Electrical World*, undoubtedly be the new gearless motor which Prof. Short has recently designed. The Short Company has undertaken the development and perfection of this machine. The first type of this motor was exhibited a year ago at Pittsburgh (see *The Electrician*, Vol. XXVI., p. 708). This motor, a four-pole machine, had an armature 24in. in diameter. The armature was of the Paccinotti type, with the field magnets, eight in number, presented on either side, and the whole encased in a cast-iron frame, and provided with a hollow shaft through which the axle of the car played freely in a flexible driving

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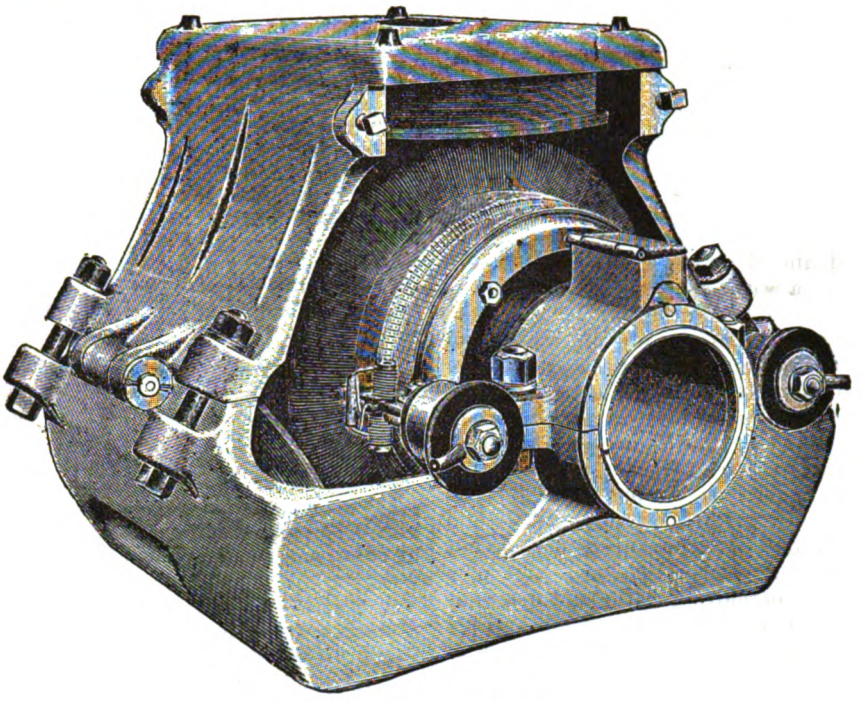
clutch. The car at the convention was provided with two of these motors, each having a capacity of 20 H.P. It was necessary to mount these motors on 36in. wheels owing to the size of the armature ring. A number of these motors were manufactured and shipped to various places, and they have now been in operation about a year, with a nominal cost of repairs. This motor, however, was not satisfactory to the Short Company, owing to its size and weight, and the cost of manufacture. A second design embodying the same principles but arranged so that the field magnets were presented to the face of the armature ring has been brought out within the year, and a number manufactured and sold. These motors were adapted to 33in. wheels, and the efficiency of the machine was increased. These machines weighed 3,000lb. Within the last three months, however, the Short Company has placed upon the market an entirely new type of gearless motor arranged for 30in. wheels, and weighing only 2,300lb., which they believe will fulfill the requirements of street railway practice, except where exceedingly low speed is required. This motor (*see* figure) is triangular in shape, and has three field magnet cores cast integrally with the frame and three consequent pole pieces, making a six-pole machine of a peculiar form. The frame is cast of the softest steel. The armature is ironclad, the wire being sunk into the metal so that it is protected magnetically. The commutator is large, and has an ample carrying capacity. Only two carbon brushes are used. The machine is entirely waterproof, and the copper on both armature and field magnets has large carrying capacity. An efficiency is claimed of nearly 90 per cent. at one part of its load, and over 75 per cent. at full load. When placed in series two of these motors will make about 10 miles an hour, with ordinary loads on level track, while in parallel they will make about 20 miles an hour. At full load these motors are designed to make 12 miles an hour when placed in parallel. The machine now ready for the market has a capacity of from 20 H.P. to 25 H.P., but motors of larger size are being designed especially with reference to suburban traffic on interurban lines where high speed is to be attained, and trains of cars are to be pulled.



The Short Gearless Motor.

A REGULATING SWITCH.

In connection with our recent remarks on switches for regulating glow lamps, the General Electric Company have sent us a resistance switch for this purpose. Knowing that not much economy could be effected, we have made inquiries about the purposes for which such switches are demanded, and we are informed by the General Electric Company that they are specially appreciated in sick rooms, where a dim light is required all night. We have made a rough test with this switch, and find that on a 100-volt circuit, the handle being moved over, as shown in the illustration, practically no resistance is interposed. On the second point the light is reduced to about one quarter, and on the third point to about one-eighth. The light yielded by the lamps when the handle is on the other points is hardly perceptible. Taking the cost of an eight-candle lamp burning for 32 hours as 8d., the cost for the same period with the handle on the second point would be about 7d., and on the third point 5½d, as against 4d. and 1d., which would obtain if the cost of the light were reduced proportionately to its amount.

In sick rooms the convenience of such an arrangement is not to be measured by the cost. With alternating currents a very slightly better result could be obtained by the use of a choking coil, as far as the watts consumed are concerned; but the whole of this saving would not be recorded on the meter, as meters are at present constructed. It should be remembered that although a gas-burner is turned down with ease, a similar reduction of efficiency takes place. Some interesting figures on the cost of gas-lighting were given by Prof. Ayrton at the Royal Institution last session; but, as far as we are aware, they have never been published. This resistance switch will carry 1½ amperes, and contains 300 ohms. The resistance is imbedded in a new patent insulator, which is expected to present several advantages over enamelled resistances.

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TRADE CATALOGUES.

When is a catalogue not a catalogue? The first answer to this question might be—when it contains no prices. But several catalogues consist, as far as they are printed, in mere lists of goods, the prices of any particular articles inquired for being filled in by hand. Others, such as the one issued recently by Messrs. J. E. H. Gordon and Co., contain only elaborate descriptions of executed contracts. A continental custom is to produce a book looking like a regular scientific treatise, but really a collection of illustrated descriptions of various instruments and machines. Provided that the work contains plenty of information we do not think that its dignity need be lowered by the addition of a few prices, but in some cases it is almost impossible to give any figures, and this especially where very large plant is dealt with. As a very remarkable specimen of a catalogue which, with one or two insignificant exceptions on the last pages, is entirely free from prices, we may mention the admirably-printed handbook of Messrs. John Musgrave and Son, of Bolton. This is devoted to high-class mill engines, and by way of assisting purchasers in making a choice of an engine suited to the work to be done, and the conditions under which it is to be used, a most useful and interesting introduction is provided, in which the use of valve-gear, the effect of clearances, drainage, steam jackets, and the proportions of cylinders are discussed. By the aid of indicator diagrams and fully worked out examples, the question, "Why are compound and triple expansion engines more economical than single cylinder (or simple engines)?" is answered. In the 16 pages devoted to this problem, we find large scale diagrams of not only from steam indicators, but graphic crank-pressure diagrams, plotted on each side of a correctly-drawn line of inertia of moving parts, and diagrams of the resultant turning moments. These diagrams have been worked out for both simple and compound engines, and are of an altogether different character from the blackboard sketches, which too often appear in text-books. Fully illustrated descriptions of important steam engines are given, together with indicator diagrams and numerous details of dimensions, a very large number of types being described. Many of the illustrations are very fine specimens of wood engraving. A number of examples of rope driving, and sectional and plan diagrams of mills, showing the distribution of power by this method, are given, together with dimensions of drums and of ropes, with their speed and the power transmitted by each. The latter part of the volume contains sections on the design and proportions of pulleys and drums, for ropes and belts, friction clutches, toothed gearing, belt driving, shafting, and 36 pages are occupied with boilers and tables of coal consumption. We wish that this book could have a wider circulation than seems to be intended. On the cover we find "With the compliments of John Musgrave and Sons (Limited)," and on the back of the title-page we read, "Price one guinea." Under these circumstances it is hardly likely to get into the hands of students and young engineers, who might get much valuable information from its pages.

Of an intermediate kind is a catalogue of Mr. Schall, which, though it contains a price list, gives an excellent account of the apparatus used for medical and surgical purposes, together with many practical hints, and an introduction giving a sketch of Ohm's law, units, &c. Very clear directions are given for connecting cells to produce different effects, with examples of the arrangement of batteries for cautery, showing the important effect of internal resistance which so often puzzles a beginner. The price list is well illustrated, and contains a great variety of apparatus.

We have been favoured with a preliminary inspection of some advance sheets of the new catalogue of the General Electric Company, of Queen Victoria-street. This, though altogether surpassing the previous catalogues of this firm, will be essentially a price list; but interspersed among the 500 pages there are many useful hints, and in some cases careful instructions on the use of the articles described. The following is an abstract of the introduction to the section on switches:—

A switch is an appliance for conveniently making or breaking an electrical circuit. We divide our switches into two classes, main switches and branch switches. The main switches are for 20 amperes and upwards, and the branch switches for circuits of smaller capacity. These switches are again divided into two classes, single pole, which break circuit on one wire only, and double pole, which make or break the contact simultaneously on both wires. Each of the above-mentioned switches is made in great variety, and for serving a number of purposes. The main switches, for instance, can be subdivided into single contact switches and multiple contact switches, the latter being used for ammeter switch, for regulating two or more circuits, and for regulating resistances or accumulator circuits. The branch switches are usually made single or double contact, with or without cut-out, as may be required, and are placed in a convenient place on the wall for controlling the various branches of the circuits. In a great many instances, however, these switches serve a special purpose, and are fixed accordingly; for instance, to a bracket (bracket switch), to a holder (switch holder), to a door (door switch) hanging from the ceiling by means of a flexible cord like a push (pear switch or pull switch). As may be judged by the great variety of switches, they form a very important part of an electric light installation, and in installations where the current is supplied from central stations, the switches are really the most important part, as they are constantly in use and almost the only appliance which is subject to direct handling on the part of the consumer. Of course, one type of switch cannot satisfy every requirement. In all of them, however, the following points have been considered:—

1. *Contact.*—Whether wedge contacts, fork contacts, or impact contact, they all should be good rubbing contacts, having large surface area compared with carrying capacity. The contact of the switch must be fully "on" or fully "off," no intermediate position must be possible.

2. *Springs.*—Owing to the necessity of a quick make or break, every switch must have some kind of a spring action. The simplest kind of spring is the most preferable. It is not so liable to get out of order, and no spring should be in tension when in the "off" position.

3. *Terminals.*—Proper terminals for easy wiring and making good contacts are most important. Those with set screws requiring no twisting of wires are the best.

4. *Handle.*—The most usual action for moving a switch is made by a turning or locking motion. The handle should be well insulated from the contacts and should be loose, that is the "off" position should be obtained independently of the handle.

5. *Bases.*—The use of china, the best insulator, has now been adopted for all our switch bases. All the metal parts are attached from the front, so that no conducting metal parts are visible at the back, and leakage through the walls is made impossible. The fixing and leading holes should be large to admit of high insulation wires.

We have no intention of criticising either the switches or the foregoing description, but take this opportunity of pointing out that in many switches, while no intermediate position is possible when turning "off," an inquisitive person can make an arc in turning "on." Some forms of impact switch get over this difficulty, but we observe that the General Electric Company introduce their pattern "to effectually meet foreign competition for a cheap switch." In saying that every switch must have some kind of spring action, large main switches may be excepted. So stiff must the contacts be, that when the switch is pulled open, it generally flies over fast enough against the stop. We are glad to find that the General Electric Company advocate set-screw terminals, and wish that these were more common than flat headed screws, with or without washers, for clamping wires. The fastening of metal parts to the front of china bases, so that no conducting metal parts are visible at the back, is an improvement which will, perhaps, some day be insisted upon by insurance inspectors.

Some useful hints are given in this catalogue about cut-outs, and explanations of their use are addressed to the uninitiated. Screw plugs and spring clips are condemned in the "general remarks on design of cut-outs," because "besides faulty contacts, the reliance on springs is always bad from an electrical point of view." This is rather a contradiction of the principles on which most switches are made, where wedge or spring contacts, between which it is difficult to discriminate, are in common use. A wedge or spring cut-out generally implies a more or less expensive fuse consisting of mica, fibre, or glass tube as a support for a wire or foil. When these are destroyed, a careless or ignorant person may replace them with a nail, or a domestic pin. The General Electric Company prefer a fuse

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which must be fastened with a screw-driver. This they claim as an advantage, "as no good electrical contact is possible without a screw-driver being used, an instrument which can be handled by anybody, and now that electric lighting has become so popular, such an instrument will be as indispensable a household tool as a knife and fork." What a shocking confession! Did we believe it for a moment we should not give it publicity. We have all heard of the heroine who averted disaster at a brilliant ball by replacing the main fuse by a hair-pin; but what if a pocket screw-driver had been necessary! The fuses recommended consist of tin wire, thinly coated with shellac to prevent oxidation. These, known as the eclipse pattern, have copper clip ends, and are arranged so that a small fuse cannot possibly be inserted in a large cut out.

THE ELECTRICAL RESISTANCE OF METALS AND THE MEASUREMENT OF TEMPERATURE.*

BY C. E. GUILLAUME.

It is with good reason that we anticipate great things from the study of metals at very low temperatures. Lead, it seems, is very sonorous at −200°C., and in proportion as the temperature is lowered the number of magnetic metals and alloys increases. The investigation of electrical resistance *promises* much. I emphasise the term designedly, although in the opinion of some electricians the recent work of Profs. Dewar and Fleming is the realisation of the most splendid promises. While recognising the great value of that research I am a little less optimistic. It is very interesting to have followed the resistance of a large number of pure metals down to −182°C. or −197°C. We know now that the resistance shows no peculiarity for 15 metals and alloys, and this ample harvest of results confirms the opinion that the best method of measuring low temperatures consists in determining the electrical resistance of metals exposed to these temperatures. Mr. Callendar had already shown the same thing in another direction by investigating the resistance of platinum up +1500°C. The platinum-resistance thermometer seems available over a range of 1,700deg. But it is precisely at the extreme temperatures of Profs. Dewar and Fleming's determinations that discussion begins. How is −200°C. practically defined? Assuming *à priori* that the hydrogen thermometer failed at a certain unknown point, Wroblewski, making use of a thermo-electric couple as control, declared it was inaccurate from −193°C., whilst I showed how another phenomenon, the electrical resistance of copper also investigated by Wroblewski, confirmed the indications of the hydrogen thermometer. Profs. Dewar and Fleming do not say how they measured their temperatures, but everything leads one to believe that they base them on Wroblewski's experiments (indications of the German silver-copper couple), that is to say by extrapolation of an arbitrary phenomenon. Now, it is highly probable that the temperature indicated by this latter as being −197°C. is in reality somewhat lower, which the experiments themselves appear to confirm. In fact the straight lines connecting the points obtained at −100°C. and −182°C. for gold and platinum leaves below it the point obtained at −197°C., which if carried on to the straight line would indicate for both a temperature approximating −200°C. The contrary indication of iron does not bring in any fresh argument because the line representing the resistance is very curved for this metal. In reality, so long as it is not proved by the theory of gases that the hydrogen thermometer is worthy of confidence below −200°C., the best means of measuring these temperatures will be the variation of the electrical resistance of some concordant metals, their variation being determined at *known* temperatures comprised between +300°C. and −150°C., a little more if possible, and extrapolated below. The first result of the experiments we are speaking of will be, therefore, to give us a thermometric scale, and not the function which connects resistance with temperature, for this latter variable is unknown.

Down to −197°C. we are nearly all agreed; but as I have remarked, it is below this that opinions differ. These will be settled the moment the resistance of half-a-dozen pure metals at the temperature of nitrogen boiling at low pressure has been determined. It is the value of this temperature which these experiments give us by extrapolation. It is highly probable that the values of M. Olzewski, which are about 10deg. lower than those of Wroblewski (−211°C. for 9mm. of mercury), will be confirmed.

The fundamental hypothesis of the research we are discussing has led the authors to commit a small error, of small importance indeed, but very apparent. The temperature of the mixture of carbonic snow and ether has been assumed to be −80°C. Now if we plot the points on squared paper, we find for all the metals that the observation at −80°C. is above the curve connecting +100°C., 0°C., and −100°C. Are we to conclude that there is an anomaly in the resistance? Evidently not. It is more logical to correct this temperature. Now this is what we get by interpolation —

Platinum	−71°C.	Tin	−74°C.
Gold	−74°C.	Bronze	−72°C.
Silver	−71°C.	Platinum, Iridium	−75°C.
Nickel	−75°C.	„ Rhodium	−70°C.

Mean −73°C.

It would therefore seem certain that the mixture in question produces a slightly variable temperature about −73°C. We shall do well for the moment to entirely disregard this point in our calculations.

The experiments of Profs. Dewar and Fleming are, as it is, very important. They will become more so and in a new direction, if the authors, so magnificently equipped, will go down another twenty degrees, unfortunately the most difficult to gain, or rather to lose.

* From *L'Industrie Electrique*, October 25th.

THE LOWEST TENDER.*

Not long since we stated that the last word remained to be said concerning the Baldwin engine contracts for New South Wales. Messrs. Neilsons' letter to the *Sydney Herald*, which, at the re-request of the firm, we publish this week, is an apt commentary on our expression of opinion. The letter possesses, however, an abstract practical interest quite apart from Sydney affairs. It directs attention once more to an old subject of discussion and contention, and raises a question which has never yet been satisfactorily settled, namely, the rights of the lowest tender. It is a matter of very great importance to engineers, and we venture to think that it may be reopened and written about with some advantage. The point at issue is, in a sense, extremely simple. Tenders are solicited for the performance of some particular work. The ruling idea is that, reversing the practice of ordinary auctions, whoever names the lowest price will secure the contract. In many cases, however, the lowest tender does not secure the contract. Of this complaint is made as a grievance; whether it is justly so regarded is, however, we think, a point which does not admit being disposed of in an off-hand fashion.

For the sake of illustration we may extend the auction simile, and regard a contract which several persons are anxious to secure in the light of an article sold to the highest bidder. In fact, it will be seen that the individuals or firms tendering are precisely in the same position as persons bidding at an auction. It is perfectly understood that unless a reserve price is put on an article it will be sold to the highest bidder. The question whether the reserve price shall be announced or not need scarcely be considered here; so long as it is made perfectly clear that the highest bidder will not necessarily secure the article for which he bids, no one can complain of being deceived or badly treated. In fact, under the 30th and 31st Vict., c. 48, the "conditions of sale" must say whether there is or is not a reserve. On the same general principle it is very frequently stated in advertisements, that the "lowest or any tender will not necessarily be accepted," and under that condition we do not think that any tenderer has legitimate cause for complaint if he finds that some other individual or firm has obtained a given contract at a higher price than that for which he had offered to do the work. Indeed, it is highly desirable in a very large class of contracts that the engineer should reserve to himself the power of declining to accept a given tender. It may, for example, be within his knowledge that the party tendering does not possess the requisite skill or capital to carry out the contract. All this is quite clear, and cannot legitimately be made the subject of discussion.

Trouble arises under a different set of conditions. Instead of tenders being asked for broadcast, a few firms of known reputation are selected. These and these alone are solicited to send in tenders. Nothing whatever is said as to what we may term a reserve price. Accordingly the tenders are sent in. Very frequently they involve in their preparation a great deal of trouble and expense. In the end the contract is awarded without any ostensible reason, not to the lowest tender, but to one possibly nearly, if not quite, the highest. There is here, at all events, an appearance of unfair dealing which is very unpleasant and most undesirable; and it is this that gives rise to strenuous assertions concerning the rights of the lowest tender. The numerous discussions which have taken place at various times all seem to rage round this one question—Has or has not the lowest tender any rights? On the one side it is urged that those who ask for tenders may with absolute propriety select whom they please to carry out their work, without regard to price; and that they are in no way bound to give any rea-

* From the *Engineer*.

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sons why they should select B instead of A or D; and that, in point of fact, a statement of their reasons for declining the lowest tender might possibly involve them in actions for libel, or inflict considerable injury on a given firm. Thus, for example, we can call to mind a case which occurred some years ago, when tenders were asked for pipes of various sizes. Only certain selected firms were named. The lowest tender was not accepted, because it came from a firm which did not possess the plant necessary for making the largest pipes in the contract; and it was believed that the contract would, as regarded these pipes, be sublet. No reason, however, was assigned for passing over its tender. It was held to be unadvisable, for sufficient reasons, to go into explanations. The mistake made here, and the hardship involved, lay in calling on this particular firm to tender at all, as the facts concerning it were all known in advance. It forms no part of our purpose to deal with cases in which something closely akin to dishonesty is the principal factor in awarding a contract. We confine our attention to those legitimate cases which occur all too frequently, and in which wrong is done by what may, in a sense, be called sheer inadvertence. Half-a-dozen firms are asked for tenders, and no trace of an intimation is to be found in advertisements, correspondence, or interviews, that the lowest tender may not secure the contract. Under these circumstances we hold that wrong may be done to the lowest tenderer, no matter how innocently; and for this reason, among others, when a firm knows that it is one of a few specially selected—and such a fact cannot be kept secret—and believes that award of the contract is certain to be secured by the lowest tenderer, very great care will be taken to prepare the estimates in minute detail. Quantities will be taken out with precision. Prices will be got at as closely as possible. Estimating clerks, the foremen of departments, the chief draughtsman, the manager, the heads of the firm will all devote days and nights of labour, when a large contract is in view, to ascertaining what is the lowest sum at which it is worth while to undertake the work. In not a few cases other contracts are neglected. Orders are refused, or quoted for at prohibitory rates, in the reasonable expectation that the prices ascertained with so much labour will be low enough to secure the contract sought. The tender is sent in; and after all it is found that the order has gone to a rival whose prices are considerably higher. It is no matter for wonder if hard things are said under the circumstances. On the other hand, however, we cannot think that a lowest tender really possesses any rights whatever. It certainly has no legal rights fixed by Act of Parliament, such as are possessed by a purchaser at an auction, nor can it be said that "trade custom" gives a right; for, unfortunately, the lowest tender is frequently passed over in favour of one which is higher, without any ostensible reason.

There is, however, a far higher standpoint from which to regard the whole question—that of the honourable man. Nothing would be easier, we think, than to make it abundantly clear that the engineer reserves to himself the right, under all circumstances, to decline to accept the lowest tender. Then firms tendering will understand that although the price to be paid is a matter of importance, it is not the only matter of importance; and that other considerations may rule the mind of the engineer in advising his clients to accept any particular offer to the exclusion of all the rest. The difficulty is, of course, that when half-a-dozen firms are all equally eminent, all equally possessed of a world-wide reputation, none of them can see any other than a pecuniary reason for accepting the offer of one and excluding those of all the others. In a word, they argue that A, B and C would all do the work equally well if they got the chance, there is no reason other than the price at which they are willing to do it that should influence the engineer in making his choice among them. It is quite certain, however, that there may be and often are reasons, and that it is highly undesirable in any case that the engineer should have his hands tied; but it is none the less clear that he ought to be very careful to make all concerned understand that the contract will not necessarily go to the lowest tender. In one word, the stipulation that the engineer will not necessarily accept the lowest contract should be invariably, instead of exceptionally, put prominently forward. Even the suspicion of unfair dealing could scarcely exist under such a rule of action.

AN ELECTRIC LIGHTING IMBROGLIO.

The following facts relating to the electric lighting of a small town within a hundred miles of the Metropolis are, we think, worth placing on record, as being sufficiently typical of the results which are sure to attend the undertaking of electric lighting in districts where the chances of financial success are of a highly speculative order. The publication of the name of the town would in no way enhance the value of this object-lesson.

The project, now two years old, for lighting the town in question by electricity, so far from being yet realised, has arrived at a very curious *impasse*. And still more oddly, everyone concerned in the matter on either side seems to be at fault. During the year 1892 the local electric lighting company obtained a Provisional Order authorising their proposed undertaking; but, of course, subject to the usual conditions laid down by the Board of Trade. One of these (Clause 7) required the Company, within six months from the date of the Order and before exercising any of the powers granted, to satisfy the Board of Trade of their ability to fully and efficiently discharge the duties and obligations imposed upon them; while a later proviso (Clause 21) stipulated that within two years of the commencement of the Order, the Company must lay down suitable and sufficient distributing mains for the purposes of general supply throughout every street specified in the second schedule, and should thereafter maintain the same. Having advanced thus far, the Company appear to have stuck fast, for not until recently do they appear to have taken any steps to comply with the preliminary conditions of the Order. Three principal streets in the town were scheduled, and a few months ago, apparently quite ignoring the requirements of Clause 7, the Company informed the Board of Trade that they were prepared to carry out a part of the work (two of the three streets), and asking the Board not to express dissatisfaction at their being unable to carry out the work over the whole area. This rather singular communication was forwarded to the Town Council, who, after much warm debate, adopted a resolution to inform the Board of Trade that they had no objection to the Company laying down mains in the two streets, provided the Board were satisfied that the Company had sufficient capital to do the work and to provide for the continuance of the supply of electricity for a reasonable period; and, further, to advise that conditions be imposed compelling the Company to lay down distributing mains and supply electrical energy over the whole area of supply within a fixed time. This resolution having been carried out, great surprise was caused by a reply from the Board of Trade (dated October 12th), stating that the Company had not yet even complied with Clause 7 of the Order, requiring them to satisfy the Board that they would be able to carry out the whole work; and further stating that the Board had no power to extend the time limited by Clause 21 (two years) for laying down mains in the streets scheduled. The discovery that the undertakers had not fulfilled the first and most important condition was startling enough, but it further appeared that the contractors had notified the Board of Trade that they were then (Oct. 7th) actually laying down mains, their letter saying that "the present works are in the nature of a pioneering enterprise; but arrangements are in hand for an early extension throughout the whole of the compulsory streets," this, notwithstanding the non-compliance with Clause 7. There was already a mystery somewhere, and a special meeting of the Town Council was convened. Then a fresh complication arose, for the Town Surveyor stated that *no* mains had been laid. The "undertakers'" letter was clear on this point, for it said, "The enclosed map shows the streets in which we are now laying mains as a commencement." It also described the system adopted, and stated that the whole of the machinery was in an advanced state of manufacture, and they expected to start lighting in the first week in December. A member of the Council (presumably a shareholder in the Company) said the contractors when they wrote that letter believed that by the time they received a reply the mains would be laid; but obviously if Section 7 had not been complied with the Company had no right to do any of the work. Moreover, although they had notified the Town Council of their intention to lay down mains, the time had not then expired within which the Council might give approval, viz., a month, and by proceeding with the work before hearing from the Council they would have rendered themselves liable to penalties; but as no mains had been laid that point lapsed. It was necessary, however, that the Town Council should deal with the Company's notice, and upon this a long and somewhat heated discussion arose. On the one hand it was urged that as the two years' limit for works had expired, and the Company had not even fulfilled the first condition of satisfying the Board of Trade as to their position, the Board should be asked to revoke the Provisional Order, and that the Corporation should take it over themselves and undertake the lighting. Then a plea was put in on behalf of the Company in consideration of the expense they had incurred, and the arrangements they had actually made; but over all hung the *crux*, which would seem to be logically and legally fatal, that the Company had forfeited their Order by their own remissness in regard to Clause 7. Furthermore, the Board of Trade had denied the possession of any power to extend the time-limit for works, and that introduced another limit of perplexity, for if the undertakers had failed to satisfy the Board within six months as to their ability to execute the Order, it is not easy to see how the question of extending the period for laying down the mains was to be solved. At any rate, the problem was too much for the Town Council, and they eventually arrived at a curious compromise by passing a resolution

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expressing regret "that the Company have not satisfied the Board of Trade that they are in a position to fully and efficiently discharge the duties and obligations of the Provisional Order," and at the same time notifying the Company that they disapprove of the Company opening up any of the streets or "commencing any other works" until they have complied with the 7th Section of the Order. The scheme is thus again at a dead-lock, for the Company have not satisfied the Board of Trade, the Board of Trade cannot (as stated) extend the time, and the Corporation will neither let the Company proceed with the work nor undertake it themselves. An impartial Committee has been appointed to confer with the Company, and it will be interesting to see the next development of this complex puzzle.

THE ELECTRICAL TRADES' SECTION.

The Electrical Trades' Section of the London Chamber of Commerce met at Botolph House, Eastcheap, on Friday last, to consider various questions in connection with the electrical industry. Major Flood-Page occupied the chair.

The SECRETARY (Mr. Kenric B. Murray) having read the notice calling the meeting,

The CHAIRMAN said, with regard to the forthcoming Exhibition at Chicago, that the members of the Section had been circularised with the view of ascertaining whether they intended to send exhibits to the World's Fair, and as no answers had been received it might be taken for granted that the electrical industry, so far as it was represented by this Section, did not feel it possible to do so. He quite endorsed Mr. Binswanger's opinion, that, if they did exhibit at all, they ought to be worthily represented. Under these circumstances, the members would understand that they would take no further step in the matter.

The SECRETARY then read the correspondence which had taken place between the Chamber and the National Telephone Company, the County Council, and the New Telephone Company, on the subject of getting the Board of Trade Bye-Laws in respect to overhead wires altered, and thanking the Chamber for what they had done.

The CHAIRMAN said that there was a pressing matter added to the agenda since Mr. Edmunds had given notice of the subjects he intended to bring forward; and as Mr. Crompton had come to the meeting specially to give some information upon it, he would ask that gentleman to address them.

Mr. R. E. CROMPTON said that it was well within the knowledge of the members that this Section had been corresponding with the Board of Trade on the subject of overhead wires with a view to getting two of its rules modified, one as to the thickness of an insulation, and the other as to the means of suspending the wires. Their representations so far had not met with success. No modification in those rules had been allowed, and they had been told, that, until the whole matter was brought before the Board of Trade, and pressure put upon that body by some authority equal in scientific weight to the authority that formulated these rules in the first instance—the Council of the Institution of Electrical Engineers—the Board of Trade did not propose to make any change in them whatever. Acting on this decision, he had gone to the Council of the Institution of Electrical Engineers and pointed out that they were doing a gross injustice to the trade in not investigating this matter. Prof. Ayrton took the matter up, and a Committee was appointed, the first sitting of which took place the previous day. He might say that there was every disposition shown, not only to examine the operation of the two rules referred to, which pressed most heavily on the electrical industry, but also to consider the whole of the regulations promulgated by the Board of Trade in reference to electrical matters, and make an official inquiry into the subject. Beyond this he could not go, as, being a member of that Committee, he naturally could not divulge what took place at its deliberations. It had been abundantly clear to him, and he thought, to everyone who had been considering this question, that they must put the whole investigation on a wider basis than they had at first intended. They must not confine it to those two rules; but the general question of how far the Board of Trade should interfere with private electrical enterprise should be very carefully considered, and after such consideration, if they found that they really had their hands tied and the progress of their industry fettered by over-regulation, they should make a stern protest against it. He thought that but for this there was every sign that the interference complained of would continue to increase in the future. His own view was that the Board of Trade had no right to interfere in the matter of electrical supply, except in so far as the safety and protection of the public interest were concerned, in respect of accounts and questions of that kind. There was never any intention on the part of Parliament that that body should have power to regulate in detail their operations by specifying what sort of conductors should be used, and other such matters. His own and one or two other firms had suffered by this over-regulation, and it was quite certain that their loss had deterred other people from following their example, and, consequently, had prevented many towns from being lighted by overhead wires. The whole subject of the Board of Trade regulations, not only with respect to overhead wires, but with respect to general electrical supply, was one that ought to be looked into most carefully by the Chamber. They could not do justice to it unless they took it in hand promptly, and appointed a small Committee, with an energetic secretary to watch the action of that Department, as well as that of the Institution of Electrical Engineers, in regard to electrical matters.

Mr. E. GARCKE said that it was an exceedingly difficult question to find a satisfactory solution to. He quite agreed with Mr. Crompton that it was a very serious matter to their industry that it had been subjected to such unusual interference and regulations. He thought it spoke volumes for its inherent strength that it had developed so rapidly in spite of that interference, and he was quite of the opinion that they should do everything in their power to minimise such a baneful influence. He did not know if it would meet Mr. Crompton's views to simply appoint a Committee for the purpose of advising the Chamber on any matters in which they were interested, and which the Board of Trade was dealing with. For the present he would like to reserve his approval of the appointment of a Committee with independent powers. If the suggestion were confined to the appointment of a Sub-Committee of this Section, for the purpose of taking the whole question into consideration, and advising as to what course should be adopted, then he was heartily with Mr. Crompton.

The CHAIRMAN said that there could be no doubt in the mind of anybody connected with electricity that this was a very important question, and it was not fair that the burden of its solution should fall entirely on Mr. Crompton's shoulders. He had had, on the previous day, a conversation with Mr. Crompton on the subject, and he would suggest that the question brought before them divided itself into two—the one having reference to the Institution of Electrical Engineers, and the other to the Board of Trade. It seemed to him that if the latter, when issuing its rules, consulted, for its guidance, such a body as the former, it was the duty of this Section to get that Institution to alter their views. They should first endeavour to convince the Institution of Electrical Engineers that they were wrong in giving the advice under which the Board of Trade sheltered itself. If the Section could get them to modify their opinions, it could approach the Board of Trade with much greater chance of success.

Mr. BEAUMONT thought it was high time that the whole question raised should be thoroughly investigated.

The CHAIRMAN said they had two courses open to them. They could either go to the Institution of Electrical Engineers, and get them to act in unison with the Chamber, or they could take an independent course and ignore that Institution and say, as electrical traders, that they would go to the Board of Trade direct.

Mr. TROITER thought that it was most important that Mr. Crompton should receive a little more assistance than had been rendered. More practical support should be given to that gentleman.

Mr. CROMPTON said that it was a real weakness to their cause that it should be so closely identified with his name. It was known by the Board of Trade and the Institution of Electrical Engineers that he was financially connected with the Chelmsford business, and there might always be a suspicion that he was not talking disinterestedly. He formally moved, "That a Sub-Committee of the Section be appointed to consider the whole question of the regulation of the Board of Trade; to confer with the Institution of Electrical Engineers; to suggest a course of action; to collect information; to submit witnesses and report from time to time to the Section."

Mr. GARCKE seconded the resolution.

The CHAIRMAN said that the Committee should be so formed as to include those who would give the best possible assistance, and would cover the whole of the electrical industry.

Mr. SWINBURNE thought that it ought to be independent. If a Committee of the London Chamber of Commerce were going to say, "We should like to support you in getting the rules as to the overhead wires altered," the other Committee would be inclined to look upon them as treating the matter from a monetary point of view. This was not a financial question, it was one of science, and their Committee ought to take up that attitude.

Mr. TROTTER ventured to go so far as to say that it ought to be considered as a matter of trade, as distinct from science.

The resolution was agreed to, and the following gentlemen were appointed as the Committee:—Messrs. Raworth, Ferranti, Gray, Pott, Wharton, Garcke, Bayley, Erskine, Swinburne, Gordon, Parker, Crompton, and General Webber.

Mr. HENRY EDMUNDS then said that at the close of one of these meetings a few months ago Major Flood-Page asked if there were any suggestions with regard to the agenda which might be useful for the consideration of this Section. He told that gentleman that he thought there were several matters, among others the stan-

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dardising of machinery, uniformity of prices, and foreign competition. With regard to the first, namely, the standardising of machinery, he had in his mind a difficulty that had been complained of by several manufacturers, the apparent thoughtlessness of consulting engineers in drawing up specifications, and making vexatious variations in detail, evidently more with the view of stamping their own individuality on the specification than considering the adaptation of the existing standard types of given makers to their requirements—for instance, in speeds and voltages of one portion of the machinery at the same time that common pressures, say, of 100 volts, were desired with relation to the outside circuit of distribution, all of which largely increased the cost of production, without any real good to the consumer, or increase in the efficiency of the plant; and he had no doubt if there could be collected from the several manufacturers in England to-day an accurate account of the distinct types of machines for the production of either alternating or direct currents ultimately to work at the same pressure as far as the lamps were concerned, they would be surprised to find the enormous number of types and variations in detail which might have been avoided, had it not been for the unnecessary variations in the specifications of different engineers. These variations had in every case lost to manufacturers considerable time in calculations and alterations of patterns and designs, and had been of no material good to the ultimate consumer. On the Continent and in America they found the practice very different from their own. The large manufacturing firms there having standard types of machines which every one knew and recognised, guaranteed to do a certain amount of work, under certain conditions, and which, in consequence, could be manufactured with much larger margins of profit, which, after all, was the point that they were all aiming at, than the multitudinous types which were found in this country. This matter did not end with the machinery, for they found the same variations in specifications for the installation of wires and cables, one engineer specifying one installation and another another, even where such cable had to be used under exactly the same conditions. It was these differences to which he wished to draw the attention of the Electrical Trades' Section of the Chamber of Commerce, as he considered that it would be well to encourage the recognition and use of standard types of electrical requisites in this country.

Mr. CROMPTON reminded them that it had been a great feather in the cap of this Section that it had done so much in connection with the screw business.

Mr. EDMUNDS said that with-regard to the second question, uniformity of prices, they stood on much more vexed and difficult ground; but the public were evidently bewildered when they saw the enormous disparity of prices tendered for the same work on the same specification, if any public or private building had to be lighted. The tenders in some cases varied several hundreds per cent., and the question had been very pertinently asked—Did electrical contractors to-day understand their business? Of course there was the contractor who imagined that the lowest tender would probably be accepted, and for the purposes of advertisement would often take work on terms which would involve considerable loss if properly carried out. But such a contractor felt that he paid for his advertisement in that way. Others would quote prohibitive prices, wishing to be in evidence, but not desiring to do that particular work. This might be taken as explanatory of the extremes of prices in the tenders for the same work. But was it not possible to encourage those who tendered a medium and fair price for the work? Of course they had no control over the decision of engineers in the acceptance of the lowest tender; but he thought that where a number of tenders for the same work varied very much on the same specification, it would often be evident that the lowest would be done at a loss, and he would ask whether something could not be done with regard to bringing about a common uniformity, or minimum of price, say, for an installation of lamps at per point, instead of the present wide range from 18s. to £2. The public were, unfortunately, as yet inexperienced in many cases as to the classes of work they get done for a given price, and were, therefore, apt to take the lowest offer, which merely encouraged bad work, slovenliness, loss, and general distrust all round. They found uniformity in other branches. The sixpenny telegram, the penny-a-mile Parliamentary train, the 3s. 9d. incandescent lamp, were all attended by beneficial results to those who did the work; and he would ask whether they were not able to bring a certain standard of work into practice, and get nearer to a uniformity of price for that standard, so that people might be discouraged from entering on work in which they would positively incur a loss?

Mr. GARCKE was afraid that a discussion on the point raised was not likely to lead to a practical conclusion. Mr. Edmunds was dealing with a question that could not be settled by the Chamber. They could not interfere with prices of work which was open to competition.

The CHAIRMAN thought it was not practicable to do anything in the way of bringing prices to a dead level. If they could give General Webber or Mr. Swinburne the control of the trade it might be done, but where they had a number of engineers to deal with it would be quite impossible.

Mr. EDMUNDS said that the next matter for consideration was the vexed one of foreign competition. It was the boast of most Englishmen that this was a free trade country, and, therefore, he felt great difficulty in introducing a question of this kind without wandering into abstract questions of Protection and other matters which had already been dealt with by men who had given years to the study of political economy; but, nevertheless, foreign competition was a very serious matter, especially with relation to goods which could not be protected by patent or design, and could not be labelled "made in Germany," or other foreign countries. The overflow goods produced by foreign makers were sold here at prices at which they would not be disposed of in their own countries, leaving little or no margin of profit, but merely enabling the foreigner to employ a larger number of hands and increase his turnover. This had a most serious effect on the profits of the English manufacturer, with a corresponding reduction in the wages of his workpeople. He admitted that it was difficult to suggest a remedy, but he found that many English buyers were beginning to be prejudiced against goods marked "made in Germany," or other places abroad, giving the preference to those manufactured here. This helped to meet the difficulty where the goods could be so marked; as, for instance, incandescent lamps which might shortly be met with stamped "made in Germany," in which case he had no doubt that the English made article would receive the preference; but when they came to goods which could not be so marked, as, for example, the manufactures that he was interested in, namely, wires and cables in their various forms, and so forth, where only the wrappers and labels could be made to indicate the place of origin, a greater difficulty presented itself. Therefore, would it be unfair to ask that as a protection to British industry all goods that could not be so marked, as to indicate to the consumer their place of origin, should have a duty imposed upon them, provided, of course, that they could be equally well manufactured here? Or could this Section indicate any other method of dealing with this matter?

The CHAIRMAN asked whether Mr. Edmunds could not devise a rule by which his wires could be identified as not of foreign make. It would be a good thing if they had a little of the patriotism that other countries had in excluding from their shores foreign manufactures.

General WEBBER said that it would be a very good idea, particularly in connection with the electrical industry, if the whole trade in England were to adopt a general trade mark, in addition to each particular firm's trade mark, so that all people would know that the article they were purchasing was manufactured in England. It would be an undoubted advantage to the industry in which they were all so much interested.

The proceedings then terminated.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 15, 1892.

Power Transmission Plants.—Some very interesting power transmission plants are now being designed or in process of construction in different parts of the country. One worth mentioning is that of Aspen, Colo., where the electric light station has for many years been remarkable, because of the extensive use made of water-power in the generation of electricity. The same company is now constructing a new plant which will furnish power for mining operations exclusively. Five Brush dynamos of 500 volts and 300 amperes each will be used; the transmission lines requiring 225,000 pounds of No. 0000 copper wire. The dynamos will be driven by five 57in. Pelton water-wheels under a head of 356ft., and developing 250 H.P. per wheel. The water is brought from separate streams by means of a 30in. pipe line, 4,000ft. long; a 24in. pipe line, 3,900ft. long; a wooden flume, 16,500ft. long; and another 12,000ft. long. Mr. C. E. Doolittle is the manager of the Company building this plant, and deserves the credit for most of the excellent work that has been done in this station since its establishment a number of years ago.

The Western Union Telegraph Company.—The Western Union Telegraph Company this week gave out a full tabulated statement of the earnings and expenditures, and other statistics of the Company for the year ending June 30th last, together with the same statistics for the corresponding

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periods of 1891, 1890 and 1889. These figures show that the Company is operating 740,000 miles of wire by means of 20,700 offices, and that during the year over 62,000,000 messages were handled. The average receipts per message were 31·6 cents, while the average cost per message was 22·3 cents. The comparisons given herewith for the four years from 1889 to 1892 show a remarkable constancy in the average receipts per message, as well as for the average cost per message. The number of messages, however, has increased from 54,000,000 to 62,000,000 during the four years. The following table shows these comparisons :—

—	1892.	1891.	1890.	1889.
Gross	$23,706,404	$23,034,326	$22,387,028	$20,783,194
Operating expenses ...	16,307,857	16,428,741	15,074,303	14,565,152
Net	$7,398,547	$6,605,585	$7,312,725	$6,218,042
Interest and S. Fund...	930,523	931,219	915,135	835,655
Balance	$6,468,024	$5,674,365	$6,397,590	$5,382,386
Dividends	4,309,638	4,309,607	4,956,008	4,309,520
Surplus	$2,158,386	$1,364,758	$1,441,582	$1,072,866
Total surplus.....	$13,576,127	$11,417,741	$10,052,983	$8,611,401
Miles wire	739,106	715,591	678,997	643,697
Offices.....	20,700	20,098	19,382	18,710
Messages.....	62,387,298	59,148,343	55,878,762	54,108,326
Tolls per message	31·6	32·5	32·4	31·2
Cost per message	22·3	23·2	22·7	22·4

Large Dynamos.—It is reported on good authority that the General Electric Company is building at its Schenectady works some railway generators of the well-known Thomson-Houston multipolar type of 1,500 kilowatts capacity. It is presumed that these machines are intended to furnish current for the electric locomotives which that company is building for the Baltimore Belt Line tunnel and for other railway plants where large motors from 500 to 800 H.P. will be used. The Siemens and Halske Company has just placed on the market some 1,000 H.P. machines, and the Westinghouse Company has built some of a similar capacity for use in the World's Fair plant. The tendency with the companies seems to be towards the construction of large machines. The Westinghouse Company is building a 500 H.P. generator of a very curious type in the plant of the Narragansett Electric Lighting Company at Providence, R.I., taking a 500 H.P. compound slow-speed engine as the basis ; the designer has arranged the armature coils upon a frame which is fitted to the periphery of the engine fly-wheel ; the field coils are thus built up on a separate resting on the same foundation as the engine, this field coil frame being movable in a direction parallel with the engine shaft. Whatever may be the outcome of the test of an alternator built in this way, the design seems to be a decidedly crude one, and reminds one of the early attempts made in the construction of electric motors to make them as near as possible in appearance and operation correspond to the existing types of steam engine. This Westinghouse machine is side by side with a Thomson-Houston alternator of the same capacity but of different design, and an excellent opportunity will be afforded of testing the relative merits of the two machines.

Multiphase Transmission.—Multiphase transmission in America has, up to the present time, been a thing much talked about, but never put in practice. We are soon, however, to have a plant on a large scale transmitting power over a distance of 11½ miles, from the waterfalls in the Farmington river to Hartford, Conn. The machines are now being constructed by the General Electric Company, and the plant to be put in service at first will comprise a generator of 300 H.P. capacity, and a multiphase motor of the same size.

The "Columbus" Week Electrical Illuminations.—The past week has been almost a continuous holiday in New York City, the city being given up for the time being to the celebration of the Columbus quadri-centennial. It was anticipated that the electrical exhibits in the way of striking illuminations would be very fine ; but the general opinion, after having seen the attempts at display, was that the whole thing was a gigantic fizzle. A few meritorious designs were shown on the front of a few prominent buildings, notably that of the Edison Building, but the illumination of the "floats" in the procession was very much below what was expected.

The Edison Lamp Judgment.—The Edison lamp decision does not seem to have affected either the stocks of the companies interested or the business which they are doing. The Westinghouse people, however, claim that they have a new lamp, which they will put on the market on December 1st, which does not infringe the Edison fundamental patent, and for which they now announce that they are ready to take orders and make contracts. No official announcement has been made of what policy the General Electric Company will pursue in dealing with the smaller lamp companies, but probably the management is wise enough to foresee that it will be more advisable to compromise on the payment of a small royalty than to shut up the factories of these companies. At any rate, such seems to be the general impression.

A New Edison Company.—It has been announced that Mr. Edison, in connection with Mr. Henry Villard and other well-known financial men, has organised a new Company, and that he will withdraw from the General Electric Company, and give his attention to the interests of the new concern, which will make a special effort to extend its business in the North-western territory of the country, a field which Mr. Edison well knows is a very profitable one for the extension of electrical industries, both in the electric railway line and power applications for mining and other purposes. This report, however, has been vigorously denied, and it is not known definitely whether the rumour is well-founded or otherwise. At any rate a company has been formed at Minneapolis with a capitalisation of $12,000,000, in which a number of electrical men and financiers are interested.

CORRESPONDENCE.

A DISAVOWAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : I see, with great regret, that my former colleague and *collaborateur* in various communications to the Institution of Electrical Engineers and other scientific societies, Dr. Arthur Harries, has issued a report in favour of the electropathic belts of Mr. Harness.

I must, therefore, ask you to be kind enough to allow me to make known, through your columns, that my connection with Dr. Harries ceased about 12 months ago.—Yours, &c.,

H. NEWMAN LAWRENCE, M.I.E.E.

THE PRINTING OF MATHEMATICAL SYMBOLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : With reference to the question of printing mathetical symbols, the solidus notation has not the disadvantage you suggest of being inapplicable when the numerator and denominator contain more than one term each, for the use of ordinary brackets prevents there being any ambiguity as to what fraction is meant : thus, $(A+B)/(C+D)$ is equivalent to $\frac{A+B}{C+D}$ and $A+B/C+D$ to $A+\frac{B}{C}+D$.

With regard to exponential expressions of the form $Aa^{f(x)}$, where $f(x)$ is any function of x, I suggest that the inverse notation $Alg_a^{-1}f(x) = Aa^{f(x)}$ offers a satisfactory solution of the difficulty, and that without the introduction of any new convention : thus the equation

$$i = \Sigma h e^{\frac{R(t-ckx}{ck^2+L}}$$

may be written

$$i = \Sigma hl g_e^{-1} \left\{ \frac{R(t-ckx)}{ck^2+L} \right\}$$

or

$$i = \Sigma h lg_e^{-1}\{R(t-ckx)/(ck^2+L)\}.$$

With regard to the notation for trigonometrical functions, I think it is a pity that it has come to be usual to write tan^2x

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for $(tan\ x)^2$, *i.e.*, for the result of operating on $tan\ x$ with $tan\ x$: the meaning naturally applicable to $tan^2 x$ is $tan\ (tan\ x)$, and on operating once with tan^{-1} on $tan\ (tan\ x)$, we get $tan\ x$ and on operating again with tan^{-1} we get x. The inverse notation $tan^{-1} x$, which Prof. S. P. Thompson deprecates, is in consonance with the ideas of the calculus of operators, and a change to the Continental notation arc $tan\ x$ would, in this respect, be a retrograde step, I think.—Yours, &c.,

HAMILTON KILGOUR.

COST OF ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may be of interest to record the result of a lengthy test to arrive at the prime cost of a Board of Trade unit of electricity when generated by means of a dynamo driven by a gas engine. The engine is a 12 H.P. nominal Otto (old type), the dynamo, a compound wound Siemens (1885 type) 160 volts, 40 amperes. The gas was measured by means of an ordinary dry meter and the electricity delivered to the cars on my Electric Railway by means of an Aron watt-meter carefully adjusted. The demand for current was of course variable, and had it been constant, the price per unit would have come out lower.

Cost of gas 2s. 9d. per 1,000 cubic feet, cost of electricity per unit 2·7 pence, add 0·1 for slide lights 2·8 pence, or 12·1 units for 1,000 c. f. gas.—Yours, &c., MAGNUS VOLK.

Brighton.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—EXTENSION OF TIME.—In *The Electrician* of August 26th, p. 469, a notification appeared that tenders for lighting the city of Belem do Gram Pará, Brazil, by gas or electricity would be received up to November 30th. This period has now been extended to December 30th. Particulars may be obtained from the Brazilian Legation or Consulate.

TENDERS ACCEPTED.—The tender of Messrs. G. Rennie and Co. has been accepted by the London County Council for a new steam ferry boat at the price of £17,500, or for £17,440 if the speed of the engine to be used for the electric lighting installation on board is to be 650 revolutions.

APPOINTMENT VACANT.—The Corporation of Oldham require an electrical engineer, experienced in the working of electrical plant, to supervise the laying of the mains, to take charge of the central station, &c. Particulars will be found in our advertising columns, and applications must be sent to Mr. A. Nicholson, town clerk, by November 2nd.

MESSRS. RUSSELL AND CO.—Under the style and title of Russell and Co., Earl Russell, who was until recently business manager for Messrs. Swinburne and Co., has commenced business at 11, Queen Victoria-street, E.C., as a general contracting electrical engineer. Little or no manufacturing business will be undertaken at present. Lord Russell has had considerable experience in electrical work.

EXTENSION OF PREMISES.—Mr. R. W. Paul, electrician and scientific instrument maker, has, owing to increasing business, been compelled to take additional premises in Leather-lane, Holborn, E.C. These new premises are situate near Mr. Paul's workshops and testing rooms in Hatton-garden, and have been fitted with steam-power and modern machine tools, &c.

EDISON GENERAL ELECTRIC COMPANY.—We have received from Mr. Philip S. Dyer a notice that on account of the recent consolidation between the Thomson-Houston International Electric Company and the Edison General Company of America (now called the General Electric Company of New York), the European business of the Company will be transferred from 34, Victoria-street, London, S.W., to 7, Rue du Louvre, Paris, where M. E. Thurnauer will represent the European interests of the Company, Mr. Dyer having given up his connection with the European agency.

REMOVAL NOTICE.—Messrs. North, North, and Co., until lately known as George North and Co., have, together with Mr. George North, removed from 90, Queen-street, E.C., to 61 and 62, Gracechurch-street, E.C.

HADWEN v. RICHARDSON (*In Chancery*).—Mr. T. W. Hadwen, the receiver in this matter, is now discharging the claims against the late firm of Messrs. A. W. Richardson and Co. Creditors will note.

THE EPSTEIN ELECTRIC ACCUMULATOR COMPANY (LIMITED).—We are asked to state that the offices of this Company have been removed from 34, Cannon-street to 19 and 21, Queen Victoria-street, E.C.

THE HEYL ACCUMULATOR.—It is stated that a large factory for the manufacture of the Heyl accumulator will shortly be established at Augsburg, Bavaria.

MESSRS. SIEMENS AND CO. (LIMITED).—An interesting article on Messrs. Siemens' and Co.'s Works at Woolwich appears in the *Belfast Evening Telegraph* of the 21st inst. This forms part of the series of articles on electric lighting which have appeared in that journal from time to time during the past month.

LIGHTING THE HOUSES OF PARLIAMENT.—In reference to a Note which appeared in our last issue respecting a special number of *Industries* dealing with the lighting, &c., of the Houses of Parliament, which was announced to be issued to-day (the 28th inst.), owing to some important alterations in the lighting arrangements which have recently been decided upon the issue of this special number is postponed till November 4th.

COUNTRY HOUSE LIGHTING.—Arisaig House, Arisaig, has recently been lighted by electricity, water power being utilised, and a saw mill being also driven by the turbine used for the lighting. The installation includes the farmhouses and stables adjoining. The contractor is Mr. Yorke, who has also completed the lighting at Inverie House, Oban.

VOLK'S ELECTRIC RAILWAY.—We have received a copy of the seventh edition of Volk's Electric Railway pamphlet, containing illustrations of the various points of interest on the line at Brighton, as well as particulars showing the cost of working, &c. The proportion of gross expenses to receipts (all repairs being paid out of revenue) represents 55 per cent. The figures given cover a period of eight years.

COMPAGNIE ELECTROMÉCANIQUE.—Ordinary and extraordinary meetings of this Company, which was formed in 1885 by Messrs. Weyher and Richemond, Menier, and Belleville, were held at Paris on Tuesday last to receive the accounts for the past year and to ratify the increase of capital caused by the inclusion of new firms. The Compagnie Continentale Edison and the Société Heilmann-Brown will take part in the Compagnie Electromécanique, the Edison Company transferring to the latter the construction of their dynamos, in order to devote their Ivry works entirely to the manufacture of electrical apparatus. It is stated that the Société Générale des Téléphones will have an interest in the Compagnie Electromécanique to the extent of 500,000 francs.

Re CHARLES JAMES ALLPORT.—This bankrupt, an electrical engineer, of Woburn-place, Russell-square, against whom a receiving order was made on May 26, 1891, has lodged with the Official Receiver a proposal for the settlement of his affairs. He proposes that a claim by the late Sir James Allport, amounting to £3,655, shall be withdrawn, and to pay 20s. in the pound upon the principal amount of the original debts due to his other creditors respectively, excluding any claim for interest. The debtor commenced business in 1882 with about £200 borrowed money. His liabilities, as shown by the statement of affairs, amounted to £14,880, with assets £43 only. The Official Receiver reports in favour of the proposal.

ELECTRIC PUMPING MACHINERY.—The Durban-Roodeport and Main Reef Companies have ordered electrical pumping machinery for their mining properties in South Africa.

PRINTING BY ELECTRICITY.—The *Bristol Times and Mirror* contains an interesting article from an American newspaper proprietor setting out the many advantages he has obtained by the introduction of electrical power for printing his journals. This installation was made on October 29, 1891, and has been a complete success.

"TEMPERED" COPPER.—We have received from Messrs. O. Berend and Co. a description of the product known as "tempered" copper, manufactured by the Eureka Tempered Copper Company, an American firm, which is now endeavouring to introduce this material for such purposes as commutators and trolley wheels, where a rubbing or rolling electrical connection has to be made. The metal is stated to be pure copper, without any alloying substance, and to owe the properties claimed for it to peculiarity of treatment rather than composition. Some months ago we caused inquiries to be made in America as to the precise nature of this treatment, but found that it was withheld as a "secret process," and no information was available. The analyses now put forward are not completely satisfactory, as they afford internal evidence of a want of precision, which impairs their value in judging the nature of a material of which nothing more definite is known. For example, it is unusual to find in a copper containing 99·981 per cent. of Cu. as much as 0·088 per cent., or nearly $\frac{1}{10}$th of a per cent., of iron, even if the fact that the whole analysis adds up to 100·154 per cent. be waived. When a degree of accuracy, represented by the use of the third

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place of decimals, is attempted, it is somewhat anomalous to find an error in the total of 154 of the same units. The differences between the analyses of tempered and of untempered copper appear to us to be of the order of experimental errors. Be this as it may, there is evidence of the mechanical tests that "tempered" copper, in the form of wire and sheet, has a high tensile strength, and the experience of users points to the conclusion that castings of it wear well. What is wanted is a trustworthy report on the chemical and mechanical properties of "tempered" copper.

CLOUD ADVERTISING.—Experiments have been made at Earl's-court during this week to show the feasibility of advertising on the clouds by means of electricity, and from an æsthetic point of view, says the *Daily Telegraph*, have proved deplorably successful. Mr. Crompton, at whose Brompton works the demonstrations of this invention have been made, does not seem to hesitate to aid and abet Mr. E. Curtice, the inventor, in thus disfiguring the firmament. The only hope, says the *Globe*, is that if the practice of advertising in the heavens should become common, the rival advertisers will make such a hotch-potch of each other's announcements that they will all give it up in despair.

ELECTRICAL OMNIBUSES.—The first fruits of the offer made by the Electrical Power Storage Company to undertake the maintenance of batteries for traction purposes are to be found in a renewed promise from Mr. Radcliffe Ward to place his electric omnibuses for public service. "Probably in a fortnight the latest electrical omnibus will be running." We have heard this so often during the last three or four years, that we should continue to wait, were it not that the Electrical Power Storage Company have apparently accepted Mr. Ward's scheme, the practicability of which thus receives a very important endorsement. He seems to have got over to some extent the large non-paying load, but he makes a humorous excuse for the 3½ tons, as compared with 34cwt. for the heaviest horse 'bus, by saying that the electrical omnibus carries its horses on board. It is strange that the Hammersmith route should be adopted, a route on which competition has been most severe, and which comprises a stiff gradient in Piccadilly.

BRISTOL.—The report of the Electrical Committee has been presented to the Bristol Corporation, and its recommendation that the tender of Mr. Hayes for £13,346 for the erection of the central station has been adopted. In moving the acceptance of this tender, Mr. Pearson stated that Mr. Hayes's tender was £200 above the lowest, but he undertook to complete the work in nine months as against twelve months by the last tenderer, and this limitation of time would be strictly enforced. The Committee would shortly have to consider the question of distributing and transforming stations, and as soon as that work had been tendered for, the whole of the works in connection with the electric lighting station would have been arranged.

CAMBERWELL.—At the last meeting of the Camberwell Vestry it was resolved to empower the General Purposes Committee to secure the services of an electrical expert to deliver a lecture in the Lecture Hall, upon "How to Light Camberwell by Electricity."

CARDIFF.—At the last meeting of the Lighting and Electrical Committee of the Cardiff Corporation, plans for the proposed electric lighting works to be erected at the Great Western Railway, at Canton, were submitted on behalf of Mr. Massey, and were approved of by the Committee. Complaints against the dilatoriness of the Gas Company were heard, and it was urged upon the Committee by several of the members that steps should be taken to press forward the question of having the district lighted by electricity.

CHISWICK.—The Local Board have received a communication from the Board of Trade in reference to Messrs. Bourne and Grant's contract for electric lighting. The contractors have, we understand, raised the question as to whether the Local Board will have a transfer which will relieve them of all responsibility with regard to the supply of the electric light, or whether the firm are merely acting as contractors to the Board, the latter taking all responsibility. The matter has been referred to the Special Committee on Electric Lighting.

DUNDEE.—Messrs. A. M'Leod, of Dundee and Glasgow, have secured the contract for lighting the large premises of Messrs. W. Hunter and Co., drapers.

EALING.—The Electric Lighting Committee have adjourned until their next meeting the further consideration of the question of the electric lighting of the district, and in the meantime are obtaining particulars relative to the probable number of consumers likely to adopt the light.

GLASGOW.—The large warehouses of Messrs. Wyley and Rockhead in Buchanan-street have been fitted from basement to garret with the electric light, the installation consisting of 16, 32, 60, 160, and 300 c.p. lamps. On Monday last the light was critically tested for the matching of colours, carpets, wall papers, &c., and gave complete satisfaction. Messrs. Mavor and Coulson are the contractors for the work.

ILFORD.—At a recent meeting of the Ilford Ratepayers' Association it was proposed that electricity should be introduced into Ilford for lighting and other purposes, under the control and management of the Local Board. Mr. Thompson, who proposed the resolution, stated that Mr. H. J. Dowsing, of Messrs. Crompton and Co. (Limited), had offered to give a practical demonstration of the facilities of electricity for lighting and power, if arrangements were made for supplying the necessary motive power. It was resolved that a small Committee of the Ratepayers' Association should be formed to consider the matter, and that the Local Board should be asked to receive a deputation on the subject.

MOFFAT.—A meeting of the ratepayers of Moffat has been held to consider whether the Police Commissioners shall be advised to take steps to light the town by electricity. Mr. D. J. Brown, a Police Commissioner, showed the facilities which the district possessed for a water-power installation, and finally the motion that the electric light be adopted was carried.

NEWCASTLE.—Dissatisfaction is expressed by the tradesmen in Gray-street, an important thoroughfare of this town, owing to the present insufficient lighting, and a deputation lately waited upon the City Lighting Committee, urging the importance of better lighting, either by gas or electricity, a strong feeling being expressed that the electric light should be used. It was pointed out by the deputation that a considerable depreciation in the value of property in the neighbourhood of Gray-street had resulted from the insufficient lighting.

PETERBOROUGH.—Efforts are being made at Peterborough to induce the Cathedral authorities to substitute the electric light for gas in the Cathedral, which is now undergoing gradual restoration.

PRESCOT AND KNOWSLEY.—The British Insulated Wire Company (Limited) of Prescot have just completed the cable for the Prescot and Knowsley Hall installation. This installation includes the lighting of a number of factory premises in the district, amongst them being the Prescot Watch Factory, which has an installation of 1,500 lights.

SOUTHAMPTON.—At the last meeting of the Harbour Board the Works Committee reported the receipt of an application for the supply of electric power on the new pier for electric launches, &c. The formal contract with Messrs. Statter and Co. for electric cranes, &c., was assented to.

TYNESIDE.—The *Newcastle Journal* of Friday last contains interesting descriptions of Messrs. Parsons and Co.'s works at Watergate, and those of Messrs. Barnett and Co., in the same district.

WYCOMBE.—At the last meeting of the Corporation, Councillor Deacon called attention to the advantages which the Council would have by keeping the Electric Lighting Provisional Order in its own hands. He believed that in a few years the light would be used in every enlightened town in the country, as it was everywhere preferred to gas, both by private and public users. Councillor Baines, in supporting his colleague, remarked that the Council had made a mistake when they lost the gas works, and would make a still greater mistake if they lost the control of the electric lighting. The proposition to apply for a Provisional Order was carried by seven votes to two.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

October 1, 1892.

17,494. H. W. HORNE. Edinburgh. Electric indicator and apparatus for cooling any part of machinery which may become heated by friction.

17,504. D. LOCH. London. Improved operating electric switch.

17,509. T. R. ANDREWS and T. PREECE. Bradford. Improvements in the construction of field-magnets of dynamo electric generators.

17,526. L. KLERITJ. London. A magnetic water gauge or indicator of level liquid.

October 3, 1892.

17,563. W. R. WYNNE. Newcastle-on-Tyne. An improved detachable lamp jointing for removable lamps for shop fronts and similar situations.

17,605. F. HARRISON. London. A new or improved automatic electric switch.

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October 4, 1892.

17,643. H. EDMUNDS. London. Improvements in electric switches.

17,647. H. HYLTON-FOSTER. London. Improvements in magneto-electric appliances.

17,653. A. J. LEHMAN. London. An improved process for treating cups, separating partitions or diaphragms, used in electric batteries or electrolytic apparatus.

17,691. L. HAVAUX. London. Apparatus for the cutting of glass by electricity.

October 5, 1892.

17,698. H. F. LEWIS and H. H. ELEY. Bristol. A new or improved polarised electrical indicator.

17,700. E. C. RUSSELL. London. An improvement in electric arc lamps.

17,717. H. J. AVERY and E. MORAND. Birmingham. Improvements in connection with electrical machines and coin-freed mechanism therefor.

17,718. H. ROSE. London. Improvements in, or relating to, electrical and mechanical telephone receivers.

17,743. E. DE PASS. London. Improvements in arc electric lamps. (L. Bardon, France.)

17,751. G. F. REDFERN. London. A door lock switch for electric lights. (C. Green, Canada.)

October 6, 1892.

17,774. E. W. COWAN and W. P. J. FAWCUS. Chester. Improvements in dynamo-electric machines and in their application to secondary battery installations.

17,826. M. HUTIN and M. LEBLANC. London. A method of transforming alternating electric currents of any tensions into continuous currents also of any tension, and conversely, and apparatus for that purpose.

17,855. T. TOMLINSON. London. Improvements in electrical distribution.

October 7, 1892.

17,877. T. R. ANDREWS and T. PREECE. Bradford. Improvements in regulators for dynamo-electric machines.

17,878. T. R. ANDREWS and T. PREECE. Bradford. Improvements in the method of, and apparatus for, starting electric motors.

17,895. F. E. ELMORE. London. Improvements in apparatus for the manufacture, electrolytically, of tubes and other articles of circular section.

17,909. C. E. CHALLIS. London. Electric switches.

17,922. F. KING and E. CLARK. London. Improvements in secondary batteries.

17,930. J. HIRSHFELD, W. MORRISON, A. P. MORRISON, and W. WRIGHT. New York (U.S.A.). Improvements in secondary batteries.

17,931. J. HIRSHFELD, W. MORRISON, A. P. MORRISON, and W. WRIGHT. New York (U.S.A.). An improvement in battery compounds.

October 8, 1892.

17,973. J. C. RICHARDSON. London. Improvements in electrolytic tanks.

17,974. P. MARINO. Surrey. Improvements in plating metallic surfaces and also prepared surfaces of non-conducting substances by electro-chemical deposition.

17,982. A. J. BOULT. London. Improvements in brushes for electric current generating and receiving machines. (L. Boudreaux, France.)

October 10, 1892.

18,025. A. B. SEE and W. L. TYLER. Manchester. Improvements in and relating to electric elevators. (Date applied for under Patents Act, 1883, sec. 103, March 14, 1892, being date of application in United States.)

18,037. W. C. MOUNTAIN. Newcastle-on-Tyne. Improvements in electric welding apparatus.

18,039. J. HARGREAVES and T. BIRD. Liverpool. Improvements in electrolytic cells and diaphragms.

18,066. F. W. GOLBY. London. Improvements in electric meters. (J. A. Dejardin, France.)

18,077. H. T. PAISTE. London. Improvements in electric switches.

October 11, 1892.

18,116. W. MATHIESON. Manchester. Improvements in, and relating to, electric arc lamps.

18,124. H. DAVIS. London. Improved electrical arrangement or device for the control of workmen's time checks.

18,142. W. A. BRAY. Leicester. Improvements in, and relating to, conduits for electric railways.

18,154. R. DRYSDALE. Birmingham. Improvements in electric arc lamps.

18,160. J. P. ANNETT. London. Improvements in telephonic receivers.

18,165. H. H. LAKE. London. Improvements in telephonic apparatus. (E. Noriega, Mexico.)

18,166. H. H. LAKE. London. Improvements in microphones. (E. Noriega, Mexico.)

18,170. E. A. DAVIS. Bristol. New or improved contacts for electrically giving signals while a door or gate is being opened.

18,179. O. SCHLICHT. London. A checking apparatus for telephones.

18,205. H. GARDNER. London. Improvements connected with machinery for making articles such as telegraph insulators from plastic material. (E. Francke, Germany.)

October 12, 1892.

18,242. T. P. RENNOLDSON. Ireland. Improvements in dynamo-electric generators and motors.

18,262. W. H. SCOTT. Norwich. Culverts for electric mains, made with pipes or tubes with insulators at intervals, arranged so that the conductors can be drawn in after the culverts are laid.

18,287. H. GARDNER. London. Improved construction of grid plates for holding the active material in secondary batteries. (E. Francke, Germany.)

18,295. A. L. FYFE. London. Improvements in methods of and means for the production electrically of spectacular effects.

October 13, 1892.

18,357. S. T. WYAND and L. SCHRAMM. London. Improvements in the construction of electrical switches.

18,359. A. L. DAVIS. London. Improvements in electric regulators.

18,363. J. P. THOMAS. London. Improvements in or relating to dynamo-electric machines.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

18,733. MARR and COLLIER. Electric telephonic apparatus.

19,546. HARTNELL. Alternating current dynamos.

20,214. WHITE. Electropathic appliances.

20,230. RIDER. Electric arc lamps.

1892.

4,185. STIENS. Galvanic battery.

14,035. PINTER. Electric incandescent lamps.

14,056. LAKE (Stanley and another). Electric motors.

14,769. THOMPSON (Cherry and others). Brushes for dynamos.

14,928. MEDHURST. Non-sparking switch.

COMPANIES' MEETINGS & REPORTS.

Eastern Extension, Australasia and China Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended June 30 last, to be submitted to the thirty-eighth ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., on Wednesday next, at 2 p.m.:—

The gross receipts, including Government subsidies, for the half-year ended June 30, 1892, have amounted to £246,988. 16s. 6d., against £264,878. 6s. 11d. for the corresponding half-year of 1891.

The working expenses, including £26,359. 9s. 5d. for cost of repairs to cables and expenses of ships, absorb £79,281. 11s. 10d., against £71,476 15s. 8d. for the corresponding period of 1891, leaving a balance of £167,707 4s. 8d. From this is deducted £3,041. 2s. 11d. for income tax, £31,895 for interest on debentures, debenture stock, and contribution to sinking fund, leaving £132,771. 1s. 9d as the net profit for the half-year.

Two quarterly interim dividends of 1½ per cent. each, amounting to £62,500, have been paid for the half-year, leaving £70,271. 1s. 9d. to be carried forward.

The contract, referred to in the last report, for the manufacture and laying on account of the Netherlands-Indian Government of a submarine cable between Acheen and the Company's system at Sumatra, has been carried out to the satisfaction of the Government, and the line opened for traffic.

During the half-year under review a further length of 443 knots of the Rangoon-Penang Cable was picked up, mostly in good condition, and taken into stock, making, with the cable previously recovered, a total of 825 knots out of 855 knots originally laid. The value of the recovered cable is estimated at £42,324, and after crediting capital expenditure with £20,000, the amount originally taken from capital towards the cost of the cable, the balance of £22,324 has been placed to the credit of the general reserve fund.

With a view to strengthening the system, a triplicate cable has been laid out of stock between Penang and Singapore. The Foochow-Shanghai section has also been partially renewed, and the route slightly altered at the mouth of the Yangtze-Kiang river, where interruptions from ships' anchors were becoming frequent. The cost of these operations, amounting to £25,974 and £5,307 respectively, has been debited to the general reserve fund.

An arrangement has been entered into with the Government of New Zealand for reducing the tariffs over the New Zealand cables from 8s. 6d. to 2s. per ten words for Intercolonial telegrams and from 1s. to 3d. per word for International telegrams, the Government guaranteeing the Company against three-fourths risk of any loss that may arise from the reductions, and the Company bearing the remaining one-fourth. It has also been arranged for the Government of New Zealand to join in the Australian guarantee and receive the benefit of the reduced rates with Australia, but owing to the losses during the first year of the experimental tariff having been greater than was anticipated by the colonies, the guaranteeing Governments have requested the Company to increase the charges for ordinary telegrams by 9d. per word, making the rates between Europe and Australasia as follows:—4s. 9d. per word for South and West Australia, 4s. 10d. per word for Victoria, 4s. 11d. per word for New South Wales, 5s. 2d. per word for New Zealand, 5s. 5d. per word for Tasmania, 9s. 5d. per word for Queensland. The changes of tariff will probably take effect from December 1st next.

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Monte Video Telephone Company (Limited).

The following is the report of the Directors of this Company to be presented at the annual general meeting, to be held at the Company's offices, 96, Gresham House, Old Broad street, E.C., on Monday, the 31st inst., at 2 o'clock :—

The accounts for the year ended July 31st last show a profit of £6,468 18s. 4d., which, including the amount of £470. 6s. 11d. brought forward from last year, leaves an available balance of £6,879. 5s. 3d., after providing for all working expenses in Monte Video and London, and after writing off £129. 12s. 2d. for proportion of preliminary expenses, and £50 for depreciation of furniture at head office and in Monte Video. As stated in the last report, a considerable reduction has been effected in the general working expenses. In Monte Video the net decrease as compared with last year is £2,000, and in London £406. This latter item is almost entirely due to the reduction and final extinction of the Managing Director's salary, Mr. E. F. Powers having resigned this position.

The lease of the central office in Monte Video expired on January 1st last, and as the landlord positively refused to listen to any new proposal on any terms whatsoever, there was no alternative but to enter into an agreement to purchase the property, the immense cost and probable loss of subscribers that would have been entailed by taking other premises quite precluding the idea of removal. After much trouble, the terms of purchase were satisfactorily concluded by a contract dated February 2, 1892, entered into with Don Francisco Alzola, the landlord of the premises, and Don Miguel Harispuru (the Company's Attorney in Monte Video), and the manager, the purchase price being $45,000, payable by monthly instalments, terminating on February 2, 1893, when the central station will become the freehold property of the Company. The total amount paid off up to the close of our financial year, viz., July 31st last, was $20,000. Our capital account has thus been increased on this account by £9,575, as shown in the balance-sheet under the head of premises account. A slight addition is also made to the same account for cost of repairs to the premises, especially the lower portion of the building, which is now in thoroughly good order, and as soon as a suitable tenant is found, will be let off at a yearly rental of £250. Considering the gloom that has been overhanging the City of Monte Video throughout the period now being dealt with, the Directors point with satisfaction to the fact that the net result of the year's working is £1,622 more than last year. As, however, the instalments on account of the premises have been paid out of the earnings of the Company, the Directors consider the right course to adopt is to recommend that the sum of £5,000, as advised by the auditors, be carried to reserve account, and the balance of £1,879. 5s. 3d. be carried forward to next year.

The Directors regret to have to report some falling off in the number of subscribers, due almost entirely to the continued great depression in business in Uruguay, which depression, in place of having decreased, as was looked for at the time of our last report, has during the past twelve months become more accentuated. As soon, however, as any general improvement takes place in Monte Video, it is confidently expected that the present number of 1,330 paying subscribers will be materially increased.

There has been some change in the composition of your Board of Directors since our last meeting. In February last Mr. Arthur Holland sent in his resignation as Chairman of the Company, and Mr. Herbert Ward was elected in his stead. Mr. T. D. Peters also found it necessary to resign his seat on the Board, being called away on business in the River Plate. Mr. C. H. Sanford has been elected a Director of your Company, and Mr. E. F. Powers, as already stated, is no longer Managing Director, but continues on the Board. During the past year your Chairman, Mr. Herbert Ward, visited Monte Video in order to inspect the management and plant, and his report informs us that he found the management perfectly efficient, and that good order prevailed throughout the Company's central and district offices.

In accordance with the Articles of Association Mr. C. H. Sanford retires *per rotâ* from the Board, and being eligible, offers himself for re-electon. The auditors, Messrs. Gérard van de Linde and Son, also retire, but offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

JOHN SAUNDERS (LIMITED).—This Company has been registered with a capital of £8,000, in £5 shares, to carry on the business of wholesale and retail ironmonger, gas, electric light, sanitary and general engineer, electric light fittings manufacturer, &c., carried on by J. F. H. Saunders, at High-street, Kidderminster.

THEWLIS AND GRIFFITH (LIMITED).—This Company has been registered with a capital of £20,000 in £10 shares, to carry on the business of tool and file manufacturers, mechanical and electrical engineers, metal workers, steel makers, &c.

UNITED ELECTRIC TRAMWAYS (LIMITED).—This Company was registered on October 22, with a capital of £30,000 in £5 shares. The objects are to acquire by purchase, lease or otherwise, tramway undertakings in the United Kingdom and elsewhere, and to develop and work the same by electricity, horse, steam or other power ; to acquire and undertake concessions, contracts, &c., for establishment, working and maintenance of tramways and to carry on the business of tramway proprietors, electrical engineers and contractors, suppliers of electricity, &c. The subscribers are :—

	Shares.
A. M. Orchard, 4, Capel-terrace, Forest Gate, E.	1
A. Wheat, Waverley High-road, Upper Clapton	1
L. du Cane, 50, Old Broad-street, E.C.	1
A. Chabot, Fernleigh, Romford	1
A. J. Kent, 8, Cross-road, South Wimbledon	1
A Robinson, 20, Erpingham-road, Putney	1

The first Directors to be appointed by the above-named. Qualification to be £50 stock or share. Remuneration, £150 each per annum (£50 per annum extra for the Chairman), and 10 per cent. of the net profits after the payment of an 8 per cent. dividend. Registered office : 37, Queen Victoria-street, London, E.C.

MISCELLANEOUS.—BAILEY'S INVENTIONS SYNDICATE (LIMITED), general engineers ; capital £2,000, in £5 shares.——BOHM AND CO. (LIMITED), glass makers, insulator manufacturers, &c. ; capital, £20,000, in £1 shares. ——FORREST AND SON (LIMITED), electric launch builders, &c. ; capital, £50,000, in £5 shares.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to August 5th, has been filed. The Company was registered on December 11, 1885, with a capital of £300,000, in £10 shares. 23,600 of the shares have been taken up, the full amount called, and all calls paid.

ELECTRIC ARMS AND AMMUNITION SYNDICATE (LIMITED).—The annual return of this Company, made up to September 12th, has been filed. The Company was registered in October, 1889, with a capital of £40,000, in £100 shares. At the time of making up, 290 shares were taken up, of which 210 were issued as fully paid. Upon the remaining 80 shares £70 per share had been called, resulting in the payment of £5,540, and leaving £60 as yet unpaid.

ELECTRIC DATE AND TIME STAMP COMPANY (LIMITED).—At an extraordinary general meeting of this Company on September 6th a special resolution was duly passed, and at a meeting held on October 4th was duly confirmed, that the Company be wound up voluntarily, and that Mr. J. M. Henderson, of 2, Moorgate-street-buildings, be appointed liquidator. The Company was registered in April, 1888, with a capital of £100,000, in £1 shares, to acquire and work Patent No. 15,717 of 1887, and generally to buy, sell, hire, let, and deal in all kinds of articles and materials capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The capital was afterwards raised to £121,000 by the creation of 21,000 deferred shares of £1 each. The last return was filed November, 1891.

ELECTRIC LAMP COMPANY (LIMITED).—An agreement recently filed between T. P. C. Crampton, electrician, and Albert Essinger and this Company states that the said Thomas P. C. Crampton is the inventor of certain improvements in electric arc lamps, and also of an improved form of carbon for use in electric arc lamps, and that the Company agrees to buy the same in consideration for 3,000 fully-paid shares. The patents are No. 10,640 (1889), for Great Britain, price £500 ; France, No. 206,804 (1890), £400 ; Austria, No. 51,074/9,903 (1891), £300 ; Italy, No. 278, 425/23, Vol. LIV./XXIV. (1890), £300 ; Spain, No. 11,027 (1890), £300 ; Belgium, No. 91,138 (1890), £300 ; Germany (not yet granted), £400 ; U.S.A., No. 442,018 (1890), £500. Registered office : 26, Thavies-inn, E.C.

ELECTRICAL INSTALLATION COMPANY (LIMITED).—The statutory return of this Company, made up to August 25th, has been filed. The Company was registered in May, 1892, with a capital of £1,800, in £1 shares. At the time of making up all the shares had been taken up, 3s. 4d. per share called, and all calls (£300) paid.

ELECTRICAL SUPPLIES AND FITTINGS COMPANY (LIMITED).—The annual return of this Company, made up to August 8, 1892, has been filed. The Company was registered in October, 1890, with a capital of £20,000, in 3,800 ordinary and 200 founders' shares of £5 each. At the time of making up 246 ordinary and 98 founders' shares had been taken up. The full amount had been called on 240 ordinary and 78 founders' shares, resulting in the payment of £1,470, leaving £120 in arrears. No calls have yet been made on the remaining shares.

ELECTRO-CHEMICAL SYNDICATE (LIMITED).—In answer to inquiries from the Registrar of Joint-Stock Companies, Mr. Lovell, solicitor to the above Company, writes that no business whatever has been transacted by the Company, which was registered in October, 1890, with a capital of £5,000 in £1 shares, to acquire certain patents, particulars of which were not given.

CITY NOTES, &c.

CALLS DUE.—*October 31 :* ISLINGTON AND GENERAL ELECTRIC SUPPLY, £1 on 45,000 £5 shares ; NEW TELEPHONE COMPANY, £2 on 48,000 £10 shares. *November 15 :* CITY OF LONDON ELECTRIC LIGHTING COMPANY, £2 on 20,000 £10 Cumulative Six per Cent. Preference.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 23 were £865, as against £756 for the corresponding period of last year, being an increase of £109. The

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total receipts for half-year amount to £13,383, against £12,171 in the corresponding period of 1891, being an increase of £1,212.

DIVIDENDS PAYABLE.—*November 1:* CALLENDER'S BITUMEN TELEGRAPH AND WATERPROOF COMPANY, 8 per cent. interim dividend for the half-year.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend for the half-year ended June 30th at the rate of 5 per cent. per annum. This dividend is payable on and after the 1st prox.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have decided to recommend the undermentioned dividends for the six months ended June 30th last:—6s. per share on the first and second preference shares, and 6d. per share on the ordinary, carrying forward £3,704.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended Oct. 21, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,486.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 19.	Price Wednesday, Oct. 26.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 26. Highest.	Lowest.
			TELEGRAPHS			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	43⅜ 50⅛	50½ 51½	4 17 1	Jan., Apr., July, Oct.	51	50½
£2,876,140	Stock	25/0	Do. Preferred	89½ 90½	91 92	5 15 5	" "	91½	90½
£2,876,140	Stock	5/0	Do. Deferred	11 11⅛	11½ 11⅞	..	" "	11 7/16	11½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11⅛ 11⅜	11 11½	6 1 9	Mar., June, Oct., Dec.	11½	11
£68,200	£100	5%	Do. 5 per Cent. Bonds	103 103	100 103	4 17 1	January and July ..	102½	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	168 173	168 173	4 0 11	Jan., Apr., July, Oct.	173	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11¼ 12½	6 19 2	February and August	12 7/16	11½
6,000	10	10%	Do. Preference 10%	17½ 18½	17½ 18½	5 8 1	" "	17⅜	..
12,981	5	1/7½	Direct Spanish (£4 paid)	3½ 3⅝	3½ 3⅝	4 16 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	.. ..	..	..
60,710	20	3/6	Direct United States	11⅞ 12	11½ 11⅝	5 19 2	Jan., Apr., July, Oct.	11 15/16	11 7/16
400,000	10	2/6	Eastern	15 15½	15 15½	4 5 3	" "	15½	15
70,000	10	6%	Do. 6 per Cent. Preference	15½ 16	15½ 16	3 15 0	" "	16	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	114⅜	113
£200,000	100	5%	Do. 5 per Cent. Debentures 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	15⅜ 15⅝	15⅜ 15⅝	4 9 7	Jan., Apr., July, Oct.	15⅝	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	109 112	109 112	3 11 5	February & August	111	110½
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	103½	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	103 106	103 106	3 15 6	February & August	103½	..
180,227	10	1 0	Globe Telegraph and Trust	10⅜ 10⅝	10½ 10⅝	4 12 10	Jan., Apr., July, Oct.	10⅝	10 5/16
180,042	10	6%	Do. 6 per Cent. Preference	15⅜ 15⅝	15½ 15⅝	3 17 5	" "	15 7/16	15 5/16
150,000	10	5 0	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	105	..
17,000	25	37/6	Indo-European	43 45	43 45	5 11 1	May and November	44	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	5 14 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 103	106 109	5 10 1	March & September	..	..
10,802	8	4/0	Reuter's	7 8	7 8	5 0 0	April and October..	..	..
3,381	£100 Cert.	30 0	Submarine Cables Trust 6%	118 122	118 122	4 18 4	" "	..	..
15,609	10	5/0	West African Telegraph	6½ 7½	6½ 7½	5 6 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	103 107	103 107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅜ 1⅝	..	" "	1 5/16	1 7/16
34,563	10	6%	Do. 6 per Cent. 1st Preference	9⅜ 10¼	10 10⅜	5 14 3	May and November	10¼	9⅜
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8⅜ 9½	8½ 9½	6 6 4	" "	..	..
64,242	15	6/0	Western and Brazilian	9 9¼	8½ 9	6 13 4	" "	9½	8 7/16
33,129	7½	1/8	Do 5 per Cent. Cumulative Preferred	6½ 6¾	6 6½	5 15 3	" "	6½	6½
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾ 3¼	2½ 3	..	" "	2½	2½
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104 107	105 108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	104 107	105 108	5 11 1	" "	107½	107
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	123 128	123 128	5 9 5	May and November	..	—
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	—
			TELEPHONES.						
40,000	£5	10/0	Chili Telephone	3 4	3 4	3 4 0	..	3⅜	..
224,800	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	6 10 10	May and November	5/16	..
x20,000	£1	4½d.	Oriental (11s. paid)	1/16 1/16	1/16 1/16	7 18 2	Yearly	..	..
438,984	5	3/6	National	4½ 5	4½ 5	6 0 0	June and December	4⅞	4⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14 14½	14 14½	4 2 9	" "	14½	14¼
15,000	10	6%	Do 6% Cumulative 2nd Pref.	13½ 14	13½ 14	4 5 9	" "	13¾	..
x20,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	111 113	111 113	3 19 8	January and July ..	111½	..
43,000	£10	..	New Telephone, Limited (£2 paid)	1⅜ 2	1⅞ 2⅛	..	..	2 1/16	1 15/16
58,000	5	1/0	United River Plate	2⅛ 2⅜	2⅛ 2⅜	..	January and July ..	2⅜	..
146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 6	—	..	—
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	10⅞ 11½	10¾ 11½	..	—	11½	11
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	—	..	—
£150,000	£5	..	Electricity Supply Company Ordinary	..	..	..	—	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	—	..	..
8,332	£5	..	House to House Electric	..	..	..	—	—	..
15,000	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5⅛ 5⅜	..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	5 4 4	January and July ..	..	..
30,000	£5	4½% '91	Liverpool Electric Supply (£3 10s. paid)	3 7/16 3 9/16	3 7/16 3 9/16	3 15 9	March	..	..
10,000	£5	4½% '91	Do. (fully paid)	5 1/16 5 3/16	5 1/16 5 3/16	4 6 9	March	..	..
111,000	5	..	London Electric Supply	13/16 1	13/16 1	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	6½ 7	6½ 7	..	—	7	6⅝
£50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	104 107	104 107	4 15 3	June and December	106	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½ 5½	5 6	—	—	..	..
18,680	£5	2/6	St. James' and Pall Mall	7½ 8	7¾ 8½	—	—	8	7⅞
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	—	—	8 1/16	..
42,853	5	3%	Westminster Electric Supply (fully paid)	5½ 6	5½ 6	2 10 0	—	5 13/16	5½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1 9/32	Brush Electrical Engineering	3 3½	3 3½	..	..	3½	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	2½ 2⅝	2⅝ 2¾	5 1 1	..	2⅝	2 7/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5 5½	5 5½	6 7 3	January and July ..	..	..
12,139	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	..	..	..
45,000	10	12/0	Electric Construction	4½ 5	4½ 4¾	..	—	4⅝	4 3/8
70,000	2	10/0	Elmore's Patent Copper Depositing	2 2½	1⅞ 2	—	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	1 2	..	..	1⅝	1 9/16
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	6 7	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	13/16 1	13/16 1	..	..	..	..
78,949	5	2/9⅜	Swan United (£3. 10s. paid)	3½ 4	3½ 4	9 12 6	May and November	3⅝	..
37,350	12	12/0	Telegraph Construction and Maintenance	44 46	44 46	5 4 4	March and July.....	45½	45
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	104 106	4 14 4	January and July ..	105	..
—	£5	15%	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	—	..	..
—	£5	8%	Do. Preference (fully paid)	.. ..	.. ..	..	—	..	..
			RAILWAYS AND TRAMWAYS.						
50,000	£10	½%	City and South London Railway	2⅛ 3⅛	3⅛ 3⅜	1 8 6	..	..	..

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